Groundwater Sampling Work Plan

for

Arrowwood Housing Sites
Naval Submarine Base New London
Groton, Connecticut

Naval Facilities Engineering Command
Mid-Atlantic

Contract Number N62467-04-D-0055
Contract Task Order 426

November 2007

TETRA TECH

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GROUNDWATER SAMPLING WORK PLAN

for

ARROWWOOD HOUSING SITES
NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION - NAVY (CLEAN) CONTRACT

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TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

TABLES

FIGURES

1.0 PROJECT INTRODUCTION

This Groundwater Monitoring Work Plan was prepared under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62467-04-D-0055, Contract Task Order (CTO) 426. The Statement of Work for CTO 426 directs Tetra Tech to develop a work plan to support four rounds of quarterly post-remediation groundwater monitoring at four properties located at the former Arrowwood Housing Sites at the Naval Submarine Base (NSB) New London in Groton, Connecticut. This Work Plan presents the technical approach for collecting and analyzing groundwater and surface water samples.

Under this Work Plan, Tetra Tech will be responsible for performing the following activities:

- Mobilizing and demobilizing;
- Measuring the depth to groundwater in 17 monitoring wells;
- Collecting groundwater samples from 16 monitoring wells;
- Collecting one surface water sample from the Beaverdam Brook wetlands;
- Analyzing all groundwater and surface water samples for the presence of VOCs and ETPH; and
- Characterizing and disposing of investigation-derived waste (IDW).

This Work Plan is divided into four sections:

Section 1.0 describes the site location and provides a brief description of the removal actions performed in 2006 at each of the subject properties.

Section 2.0 presents the Site Management Plan and Groundwater Monitoring Plan as one, integrated approach for conducting fieldwork activities. The plan addresses the project organization and responsibilities of personnel engaged in performing field investigation activities; the projected field operations schedule; and site access and security. The plan also provides detailed guidance on how activities will be performed to meet the objectives of the groundwater sampling. This Work Plan will be used by Tetra Tech field personnel as a guide for performing all field activities according to designated, accepted protocols.

Section 3.0 presents the Quality Assurance Project Plan (QAPP). The QAPP discusses project objectives, and quality assurance/quality control (QA/QC) protocols to be used to achieve the data quality objectives (DQOs). The QA/QC requirements outline procedures and methodologies to be employed by Tetra Tech to ensure the technical integrity of analytical data, evaluation procedures, sampling and analytical procedures, and site records.

Section 4.0 provides a description of the Monitoring Report that will be written to document the quarterly monitoring that is completed at the Arrowwood Housing Sites.

Appendix A consists of example field forms that will be used during groundwater and surface water sampling activities. Standard Operating Procedures (SOPs) that will be followed during the field investigation are presented in Appendix B.

1.1 SITE BACKGROUND INFORMATION

Naval Submarine Base (NSB) New London is located in Groton, Connecticut on the east bank of the Thames River approximately 6 miles north of Long Island Sound (Figure 1-1). NSB is the home port for attack submarines with the main base occupying more than 687 acres. An additional 530 acres are used for housing Navy families.

The Arrowwood Housing Sites are located on Arrowwood Drive within the Nautilus Park housing area approximately 1 mile south of the NSB, to the east of Connecticut Route 12 (Figure 1-2). These properties are the former site of several duplex residential dwellings for NSB personnel. The structures on the Arrowwood Housing Sites have been demolished as part of the redevelopment of this area, and new townhomes have been constructed on many of the properties.

Several of the properties on Arrowwood Drive have been impacted by releases of fuel oil from underground storage tanks (USTs). From May to July 2006, the Navy performed removal actions at 11 properties located on Arrowwood Drive. Removal activities included the excavation of petroleum-impacted soils until field screening indicated that the limits of the release area had been reached. The Navy collected confirmatory soil samples for laboratory analysis from the sidewalls and bottom (where practical) of the soil excavations and backfilled the excavations with clean material. A total of approximately 1,750 tons of petroleum impacted soils were removed and disposed during these removal actions (TtEC, 2006).

Groundwater was encountered during soil excavation at seven of the Arrowwood Drive properties. Groundwater (present as surface water at the bottom of soil excavation) samples were collected from these properties and analyzed for Extractable Total Petroleum Hydrocarbons (ETPH) during removal activities. At four of these properties, the concentration of ETPH detected in groundwater samples exceeded the Connecticut Department of Environmental Protection (CTDEP) GA/GAA Groundwater Protection Criteria (GWPC) of 500 ppb, which is the remediation goal for the site. Groundwater samples collected from these four properties did not exceed the CTDEP Residential Volatilization Criteria (VC) (TtEC, 2006). At a fifth property, the excavation of petroleum-impacted soils destroyed monitoring wells that were being utilized for an existing post-remediation monitoring program (HRP, 2006).

In the following sections, a more detailed description of the removal actions performed to date at the four subject properties is provided.

1.1.1 47/49 Arrowwood Drive

On 1 June 2006, the Navy excavated a 20 x 30 x 8-foot deep area of clean overburden from the 47/49 Arrowwood Drive property. Petroleum-impacted soils were encountered at 8 feet below ground surface (bgs) and soil excavation continued to approximately 15 feet bgs. The final size of the soil excavation was 20 x 30 x 15 feet deep (TtEC, 2006).

Groundwater was encountered at 10 feet bgs during excavation at this property. A visible oil sheen was detected on the surface water that accumulated in the excavation, and a sample of this water was collected. The water exhibiting a sheen was extracted from the excavation into a vacuum truck for off-site disposal, and a second sample of the water within the excavation was collected. The concentration of ETPH detected in both of these samples exceeded the CTDEP GA/GAA GWPC (TtEC, 2006).

After the collection of water samples, the soil excavation was backfilled with bank run gravel to the top of the water table, and the excavation was backfilled to original grade using native overburden material (TtEC, 2006).

1.1.2 109/113 Arrowwood Drive

Data from a previous investigation indicated the presence of petroleum-impacted soils to the east of the former UST location at the 109/113 Arrowwood Drive property. On 31 May 2006, the Navy completed a 40-foot wide excavation at this property to remove petroleum-impacted soils. Impacted soils were encountered at 5 feet bgs, and excavation continued until soil screening with the PID indicated levels below 1 ppm/v. Sidewall and bottom soil confirmation samples were collected to verify the limits of impacted soils. The total depth of excavation was 9 feet bgs (TtEC, 2006).

Groundwater was encountered at 6.5 feet bgs during excavation at 109/113 Arrowwood Drive. A visible oil sheen was detected on the surface water that accumulated in the excavation, and a sample of this water was collected. The water exhibiting a sheen was extracted from the excavation into a vacuum truck for off-site disposal, and a second sample of the water within the excavation was collected. Laboratory results from both of these water samples indicated that the concentration of ETPH in groundwater was still above the CTDEP GA/GAA GWPC (TtEC, 2006).

After the collection of water samples, the soil excavation was backfilled with bank run gravel to the top of the water table, and the excavation was backfilled to original grade using native overburden material (TtEC, 2006).

1.1.3 122/124 Arrowwood Drive

A release of No. 2 fuel oil occurred at 122/124 Arrowwood Drive (date unknown), which resulted in the removal of the tank in March 2002. During removal of the tank, approximately 250 tons of petroleum-impacted soil was excavated and free-phase petroleum was encountered at the groundwater surface within the tank excavation. This material was removed by vacuum truck. In March 2002, a 10-inch diameter recovery/monitoring well (MW-1) was placed in the excavation area. Two additional monitoring wells (MW-2, MW-3) were also installed. In April-June 2002, a site investigation was performed, five monitoring wells were installed (MW-4 through MW-8), and soil samples were collected. In October 2002, monitoring wells MW-9 and MW-10 were installed. Four additional wells (MW-11 through MW-14) were subsequently installed to further investigate impacts to groundwater at 122/124 Arrowwood Drive (TtNUS, 2006).

After removal of the UST, groundwater samples collected from monitoring wells located in the vicinity of 122/124 Arrowwood Drive indicated concentrations of ETPH above CTDEP GA/GAA GWPC. EA Engineering, Science, and Technology (EA) prepared a Corrective Action Plan (CAP) in 2003 recommending that monitoring wells be sampled for comparison to CTDEP GA/GAA groundwater standards for benzene, toluene, ethylbenzene, and total xylene (BTEX), extractable total petroleum hydrocarbons (ETPH), and methyl-tert butyl ether (MTBE). The CAP also recommended denitrification-based bioremediation (DBB) for the dissolved-phase and sorbed-phase petroleum contamination. DBB treatment was conducted from November 2003 through July 2004 and results are detailed in the Post-Treatment Sampling and Assessment Report (EA, November 2004).

Based on the results of the DBB, EA recommended quarterly monitoring for 1 year at nine monitoring wells and at one surface water location for EPTH, BTEX and MTBE to verify the effectiveness of the treatment effort. Three of the four planned quarterly rounds of sampling were performed prior to the soil removal activities discussed in the following paragraph. Results from groundwater and surface water sampling performed in September 2005, December 2005, and March 2006 (prior to soil removal) are summarized on Tables 1-1 and 1-2, respectively. The analytical results from these three rounds of samples indicated that only EPTH was present above the GA/GAA GWPC (HRP, 2006).

In May 2006, the Navy excavated a large area of petroleum-impacted soils resulting from the release at 122/124 Arrowwood Drive. The excavation area extended beneath Arrowwood Drive onto the 131/135 Arrowwood Drive property, encompassing an area of approximately 5,000 square feet. Sidewall and bottom confirmation samples were collected from the entire excavation area and sent to the laboratory for analysis. Only one confirmation sample contained a concentration of ETPH above detection limits (20 ppm, which was below remediation goals).

Groundwater was encountered at 4 feet bgs during excavation at 122/124 Arrowwood, and a sample was collected for laboratory analysis. The sample contained 377 µg/L ETPH, which is above the GA/GAA GWPC for ETPH of 100 µg/L. Since concentrations of ETPH are present above the GWPC at this property, groundwater monitoring is required to comply with Connecticut regulations.

1.1.4 191/195 Arrowwood Drive

On 16 May 2006, the Navy began the removal of petroleum-impacted soils at 191/195 Arrowwood Drive. Impacted soils were encountered at 4 feet bgs and excavation continued to the depth of bedrock (12 feet bgs). The Navy field-screened soils during excavation using a PID and continued excavating until PID readings from excavated soils were below 10 ppm/v. After all of the impacted soils were removed, confirmation samples were collected from the excavation at a rate of one per 20 linear feet of excavation sidewall to verify the attainment of cleanup goals. Confirmation samples were collected from immediately above the water table.

Groundwater was encountered at approximately 8 to 10 feet bgs during soil excavation at 191/195 Arrowwood Drive. A visible oil sheen was detected on the surface water that accumulated in the excavation, and a sample of this water was collected. The water exhibiting a sheen was extracted from the excavation into a vacuum truck for off-site disposal and a second sample of the water within the excavation was collected. Laboratory results from both of these water samples indicated that the concentration of ETPH in groundwater was still above the CTDEP GA/GAA GWPC (TtEC, 2006).

After the collection of water samples, the soil excavation was backfilled with bank run gravel to the top of the water table, and the excavation was backfilled to original grade using native overburden material (TtEC, 2006).

1.2 ENVIRONMENTAL SETTING

A brief description of the environmental setting in the Arrowwood Drive area is presented in this section.

1.2.1 Site Topography

In general, the topography of the Arrowwood Drive area slopes downward from a high along Gungywamp Road toward the Beaverdam Brook wetlands located to the south. Currently, the northern portion of the Arrowwood Drive complex and the areas immediately north of the wetlands are relatively flat, with most of the relief occurring in the central portion of the complex. Some re-grading occurred during demolition and redevelopment of the Arrowwood Drive residences.

1.2.2 Site Geology

According to the Geologic Map of the Uncasville Quadrangle, Connecticut: Surficial Geology (Goldsmith, 1960), the native surficial materials within the area occupied by the Arrowwood Housing Sites consist of ground moraine deposits consisting of till varying from light-grey sandy gravelly till to a compact, gray fissile till containing more silt and clay size particles. Surficial materials within the limits of soil excavations consist of bank run gravel that was used as backfill material.

1.2.3 Bedrock Geology

According to the Bedrock Geological Map of Connecticut, the Mamacoke Formation underlies the Arrowwood Housing Sites. The Mamacoke Formation consists of inter-layered light to dark gray, medium-grained gneiss and Potter Hill Granite Gneiss, a light-pink to gray, tan weathering, fine- to medium-grained, well-foliated granitic gneiss (CGNHS, 1990). During soil removal at 191/195 Arrowwood Drive, bedrock was encountered at approximately 12 feet below ground surface (TtEC, 2006).

1.2.4 Site Hydrology

Groundwater elevation measurements obtained by HRP Associates during groundwater monitoring at 122/124 Arrowwood Drive indicated that groundwater flow is from northwest to southeast in the 122/124 Arrowwood area. Groundwater depths in this portion of the Arrowwood complex were measured between 3 and 6 feet below ground surface.

1.2.4.1 Groundwater Classification

Groundwater beneath the Arrowwood Housing Sites is classified by CTDEP as GAA. The GAA classification applies to groundwater that may be used as a current or future public water supply suitable for drinking without treatment, or that is hydraulically connected to a surface water body that is used as a drinking water supply. Groundwater sampling results that are obtained during this project will be compared to CTDEP Remediation Standard Regulation (RSR) criteria that have been developed to evaluate groundwater in a GA/GAA groundwater area:

- Ground Water Protection Criteria (GWPC) – These criteria are intended to be protective of groundwater that is used as a drinking water source and for other domestic uses.

- Surface Water Protection Criteria (SWPC) – These criteria are intended to protect the existing use of a surface water body, wetland, or intermittent stream into which groundwater discharges.

- Volatilization Criteria (VC) – These criteria are intended to protect the occupants of buildings or future buildings from the migration of volatile organic compounds (VOCs) from groundwater into a building or other permanent structure.

1.2.4.2 Surface Water Classification

The surface water classification of Beaverdam Brook, located to the south (downgradient) of the Arrowwood Housing Sites, is AA. The AA classification indicates that the surface water present in this area may be used as an existing or proposed drinking water supply, a fish and wildlife habitat, for recreation, or as a supply for agricultural and industrial applications.

1.3 OBJECTIVE AND OVERVIEW OF FIELD ACTIVITIES

The purpose of the activities outlined in this Work Plan is to collect groundwater and surface water samples to support compliance monitoring at four former Arrowwood Drive properties where petroleum-impacted soils were removed during the spring and summer of 2006. Four rounds of quarterly sampling will be conducted to evaluate the effectiveness of soil remediation at these four properties.

2.0 SITE MANAGEMENT/FIELD SAMPLING PLAN

This section presents the project organization, personnel responsibilities, schedule, and site control subjects. This section also includes sampling and analytical objectives, sampling locations, methods, Quality Assurance/Quality Control (QA/QC) requirements, and field activity procedures.

2.1 PROJECT ORGANIZATION AND SCHEDULE

This section describes the project organization and schedule, including responsibilities of the personnel involved in performing the field work. Key project personnel and their responsibilities are outlined below.

2.1.1 Personnel Responsibilities

A Field Operations Leader (FOL) will supervise the Tetra Tech field personnel conducting the work outlined in this Work Plan. The FOL will report directly to the Tetra Tech Project Manager. Responsibilities of the FOL include supervising field operations; ensuring the procedures specified in the Work Plan are properly implemented (and if any field changes need to be made, a Field Modification Record (FMR) will be processed and approved); maintaining daily sample collection and shipping schedules; and reporting to the Project Manager on a regular basis regarding the progress of the field activities.

A Site Safety Officer (SSO) will be appointed from the Tetra Tech field team personnel. The SSO will assist in implementing the Health and Safety Plan (HASP). The SSO will report directly to the Tetra Tech CLEAN Health and Safety Manager on any health and safety issues. The SSO will also report any hazards, injuries, or decisions to stop work to the FOL whom, in turn, will contact the Tetra Tech Project Manager. The overall Tetra Tech project organization and responsibilities of key management personnel are discussed in Section 2.0 of the Implementation Plan for CTO 426, dated April 26, 2007.

2.1.2 Schedule

The schedule for CTO 426 includes quarterly monitoring events during the months of November 2007, February 2008, May 2008, and August 2008. Data analysis and validation will occur after each sampling round, but a data report will not be developed until all four rounds of sampling, analysis, and validation have been completed. The estimated deliverable date for the results report is October 2008.

2.2 SITE CONTROL

The following subsections contain information regarding the control of activities at the Site.

2.2.1 Site Access

The Arrowwood Housing Sites are located on Navy-owned land, therefore property access agreements are not anticipated to be necessary for this work.

2.2.2 Utility Clearance and Other Permits

The activities included in this Work Plan do not require any digging, drilling, or other subsurface exploration. Therefore, utility clearance will not be necessary prior to sampling.

2.2.3 Field Office/Command Post

Support vehicles and associated facilities will be sited at various locations on the Arrowwood Housing Sites depending upon where work is being performed. Investigation-derived waste (IDW) containers will be staged at an on-site location approved by the Navy until waste characterization is complete and they can be removed from the site for proper disposal.

2.2.4 Site Security/Control

As directed by the FOL, all removable Tetra Tech equipment will be returned to the Tetra Tech field office (i.e. stored and locked in field support vehicles) and secured at the end of each working day. Unfinished work and work areas will be secured each day to prevent tampering or accidental injury to the public. Appropriate security measures such as fencing, barricades, caution tape, or storage containers will be used to secure work and staging areas.

2.3 FIELD INVESTIGATION ACTIVITIES

The field investigation activities consist of the following subtasks:

- Mobilization;
- Measurement of groundwater elevations;
- Groundwater sample collection;
- Surface water sample collection;

- Characterization and disposal of IDW; and
- Demobilization.

2.3.1 Mobilization/Demobilization

This section describes the mobilization of both Tetra Tech personnel and Tetra Tech subcontractor personnel.

2.3.1.1 Tetra Tech Mobilization/Demobilization

Prior to beginning any field work, all Tetra Tech field team members will review the Statement of Work (SOW), this Work Plan, the HASP, and all applicable Standard Operating Procedures (SOPs). In addition, the SSO and FOL will hold a field team orientation meeting prior to beginning the field work to familiarize personnel with the scope of the field activities.

Equipment mobilization may include, but will not be limited to, transporting and preparing the following equipment:

- Field screening equipment
- Health and safety equipment
- Decontamination equipment
- Subcontractor equipment (to be conducted by the subcontractor)

The FOL will coordinate the Tetra Tech mobilization. The FOL will also coordinate any equipment purchases and rentals necessary to conduct the field investigation.

2.3.1.2 Subcontractor Mobilization/Demobilization

A subcontractor will be procured for IDW characterization and disposal. Once the procurement process has been completed, a "Notice to Proceed" will be issued by Tetra Tech to the selected subcontractor to mobilize to accomplish the subcontracted work. The IDW disposal subcontractor will be responsible for mobilizing and demobilizing the equipment and personnel necessary to perform the work outlined in the statement of work, including any permits required by federal, state, and local authorities.

2.3.2 Measurement of Groundwater Elevations

Groundwater level measurements will be collected from 17 on-site monitoring wells to enable the development of groundwater elevation contours and an interpretation of groundwater flow direction. Groundwater level measurements will be performed prior to the collection of groundwater samples using the following procedures:

- The well number, time, date, and any observations will be recorded on the Groundwater Level Measurement Log Sheet (Appendix A).

- Open the well lock and cap and slowly lower the downhole probe into the well. Upon reaching the water table, the depth to water (measured from the surveyed reference mark on top of the inner polyvinyl chloride [PVC] casing) will be read directly from the groundwater level indicator tape and recorded onto the Groundwater Level Measurement Log Sheet.

- Record static groundwater level and total depth of the well to the nearest 0.01 foot (0.3 cm).

- Decontaminate groundwater level indicator and measuring tape (in accordance with Section 2.6.2) prior to proceeding to the next well.

Groundwater level measurements will be collected from all 17 wells within a one-hour time frame during each monitoring event.

2.3.3 Collection of Groundwater Samples

The objective of the groundwater sampling program is to verify that the removal of petroleum-impacted soils from the Arrowwood Housing Sites has adequately remediated the releases of petroleum that occurred from USTs at these sites.

2.3.3.1 Groundwater Sample Collection and Analysis

Groundwater samples will be collected from one existing well (MW-14) and 15 new wells installed during monitoring well installation activities described in the *Well Installation Work Plan* (Tetra Tech, 2007). Groundwater samples will be collected in accordance with the procedure outlined in EPA's Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells (Appendix B).

Work elements for the well sampling activity include the following:

- Prior to purging, the depth to groundwater (measured from the top of casing) and the bottom depth of the well will be recorded to the nearest 0.01 foot using an oil-water interface probe to determine if non-aqueous-phase liquids (NAPL) are present (see Section 2.3.2). The probe will be decontaminated prior to use and between use in each well according to the procedures outlined in Section 2.6.2. The presence of NAPL and the depth to groundwater will be recorded on the Groundwater Level Measurement Log Sheet (Appendix A);

- During purging, measurements of pH, oxidation-reduction potential (ORP), temperature, specific conductance, dissolved oxygen (DO), turbidity, water level, and pumping rate will be recorded every 3 to 5 minutes (or as appropriate) during extraction of water from the well. Purging will be considered complete when parameters have stabilized (pH within 0.1 units, specific conductance and temperature within 3 percent, DO within 10 percent, ORP within 10 millivolts [mV], and turbidity within 10 percent for values greater than 1 nephalometric turbidity unit [NTU]). Instrument readings will be recorded on the Sample Log Sheet – "Low-Flow" Groundwater (Appendix A). If the monitoring well dewaters while pumping, the monitoring well will be allowed to recharge then pumping will resume. If a monitoring well continues to dewater, then it will continue to be evacuated and allowed to recharge until a minimum of two casing volumes has been removed, then groundwater samples will be collected;

- All groundwater samples will be analyzed for VOCs and ETPH. Table 2-1 presents the estimated number of field samples and QA/QC samples to be collected, the analyses to be performed, and the associated analytical procedures. Table 2-2 presents the general sample container types, preservative requirements and the maximum holding times for associated analyses;

Groundwater contaminants of concern and other target analytes are presented on Table 2-3.

2.3.3.2 Sample Documentation

A Sample Log Sheet – "Low Flow" Groundwater (Appendix A) will be completed for each groundwater sample collected. Information recorded will include that which is specified for the EPA low flow sampling procedure and type of analysis to be performed.

2.3.4 Collection of Surface Water Samples

One surface water sample will be collected from the Beaverdam Brook wetlands. The sample will be collected from the existing ¾"-diameter PVC pipe that was installed into the wetlands at a surface water sampling location that had been utilized during monitoring for the *in-situ* bioremediation project. A water sample will be collected from this pipe by evacuating it using a peristaltic pump, then allowing it to recharge. When a sufficient volume of water has recharged into the pipe, an aliquot of water will be extracted so that water quality parameters can be measured (temperature, pH, specific conductivity, and turbidity). After recording these parameters on a surface water sample log sheet (Appendix A), a second aliquot will be extracted from the pipe, containerized into pre-preserved sample containers, and shipped to a laboratory for VOC and ETPH analysis (Table 3-3 and 3-4). A duplicate sample will be collected from the pipe by repeating this sample collection procedure.

2.3.5 Control and Disposal of Investigation-Derived Waste (IDW)

Waste liquids (i.e. purge water) will be collected and containerized in 55-gallon steel drums and transported to a designated staging area where they will be staged in a locked 8-foot by 20-foot portable storage container. The waste fluids will be temporarily stored at the staging area until the laboratory analytical reports are received and their disposition is determined. Once characterized, waste liquids will be disposed in accordance with state and federal requirements.

Personal protective equipment (PPE) waste generated during work will be decontaminated, double-bagged in plastic bags, and disposed in an industrial dumpster at the completion of work.

2.3.5.1 Storage of IDW

The following NSB New London requirements for the storage of IDW in off-base areas will be implemented during the investigation:

- IDW containers will be stored in an area that is sheltered from the weather, under lock and key, accessible only to the Navy and its contractor. All containers of liquid waste will be stored in an area that provides secondary containment which is capable of holding 10 percent of the total waste capacity or is equal to the largest container capacity, whichever is greater.

- All IDW containers will be inspected prior to use to ensure that they are in good condition.

- All IDW containers greater than 26 gallons will be DOT approved.

- All IDW containers will be closed at all times except when adding or removing waste.
- All IDW containers will be labeled with a fully completed IDW Waste Label (Section 2.3.6.2).
- A field notebook will be kept on-site documenting the volume and disposition of all IDW generated during the investigation.
- IDW will be stored separately from other materials.

2.3.5.2 Drum Labeling

All soil and water generated during drilling activities will be placed in drums as appropriate. After IDW is drummed and the lid clamped tight, the drum will be labeled and marked using a waterproof indelible ink marker with the following information:

- Site name
- Date first accumulated: e.g. 10/22/07
- Drum number (each drum will be given a unique identification number)
- Source(s) of IDW: Soil boring/monitoring well ID# (see Section 2.4)
- Volume(s) of soil or water: e.g. 5 gallons/sample ID#
- Generator contact information

Drum labeling is necessary to identify materials stored in the drums and to evaluate how the drummed material will be sampled for waste characterization.

2.3.5.3 Transportation and Disposal Subcontractor

A licensed hazardous waste transportation and disposal subcontractor will be required to transport and dispose of any non-hazardous and hazardous waste streams generated during the investigation. A subcontractor will be procured to transport the IDW waste to approved off-site disposal facilities. The subcontractor will be procured to provide transportation and proper disposal locations (which will require Tetra Tech and Navy approval) for any waste liquids developed during sampling.

2.3.5.4 Waste Manifesting Compliance

One hazardous waste manifest will be prepared by the transportation and disposal subcontractor for each shipment of hazardous IDW leaving the Site. Manifests will be completed for all hazardous wastes disposed off site, and must be signed by a Navy representative. Hazardous wastes are not anticipated to be generated during this field effort.

If waste characterization analysis of the IDW indicates that it is non-hazardous, the IDW will be shipped from the Site under a Bill of Lading prepared by the transportation and disposal subcontractor for each shipment of IDW leaving the Site. The Bill of Lading will be signed by a Navy representative. Copies of all documentation of control and disposal of IDW generated by the project will be maintained in the project file located at the Tetra Tech Wilmington office.

2.4 SAMPLE LOCATION IDENTIFICATION SYSTEM

Figures 2-1 through 2-4 show the locations of monitoring wells on each of the four subject properties. Each sample collected from the site will be assigned a unique sample location tracking number. The sample location tracking number will consist of a four to five-segment, alphanumeric code that identifies the Site, sample medium, specific sample location identifier, sample event or sample depth or the quality control (QC) sample designation, as appropriate. Any other pertinent information regarding sample identification will be recorded in the field logbooks or on sample log sheets.

The alphanumeric coding to be used in the sample location numbering system is explained in the following diagram and the subsequent definitions:

AAA	-	AA	-	(AANNN)	-	(YYYYMMDD)
(Site ID)	-	(Medium)	-	(Location)	-	(Date)

Site identifier: "AWD" for Arrowwood Drive

Medium identifier: "GW" will be used for groundwater samples collected from monitoring wells, "SW" will be used for surface water samples.

Sample location identifier: Sample location designations are shown on Figure 2-1 through 2-4.

Date: The date of sample collection will be included in the sample tracking number.

For example, a groundwater sample collected from monitoring well MW201 on November 16, 2007 would be designated as:

AWD-GW-MW201-20071116

A surface water sample collected from sampling location SW-1 on November 16, 2007 would be designated as:

AWD-SW-SW1-20071116

The first duplicate groundwater sample will be designated as:

AWD-GW-DUP-01.

QC Sample Designation, if applicable:

DUP = Duplicate
TB = Trip Blank

The duplicate source will be recorded on the field data sheet.

2.5 QUALITY CONTROL SAMPLES

The quality control (QC) samples that will be collected or generated during the groundwater and surface water sampling activities are described below. A detailed discussion of the objectives, procedures, and collection rates for each type of QC sample is provided in Section 3.2.5.

Trip Blanks: Samples will be submitted for VOCs, therefore, trip blanks are required in each cooler that contains samples for VOC analysis.

Field Duplicates: Field duplicates will be collected at a rate of one for every 10 samples per matrix and per analysis. The field duplicates are collected as collocated samples. Collocated samples are collected by collecting two groundwater samples one after the other.

Laboratory Quality Samples: Additional sample volume will be collected at the rate of one in 20 samples per analysis for laboratory quality control. Triple water volume is required for organic matrix spike and matrix spike duplicate analysis.

Rinsate Blanks: Rinsate blanks are obtained under representative field conditions by running analyte-free deionized water through sample collection equipment after decontamination, immediately before sampling, and collecting the sample in the appropriate sample containers for analysis. These samples are used to assess the effectiveness of decontamination procedures. Groundwater samples will be collected using peristaltic pumps, and the sample collection tubing which contacts the groundwater will be changed between wells, therefore decontamination will not be necessary and rinsate blanks will not be collected for this project.

Fi ld Blanks: Field blanks consist of the source water that is used in decontamination (including analyte-free deionized water, potable water from each source, and other waters used in decontamination operations). Since decontamination will not be necessary during groundwater sampling at these sites (see above), field blanks will not be collected.

2.6 EQUIPMENT DECONTAMINATION

This section provides guidelines for decontamination of equipment used during the field investigation. Personnel decontamination issues will be discussed in the HASP.

2.6.1 Decontamination of Groundwater Pumps

Peristaltic pumps will be used to obtain samples from the monitoring wells installed on site. Peristaltic pumps do not require decontamination procedures, since the tubing which contacts the groundwater is changed between wells to be sampled.

2.6.2 Instrument and Meter Decontamination

Water level meters and oil-water interface probes will be decontaminated using the following steps:

1. Rinse with potable water
2. Rinse with 2-propanol
3. Rinse with deionized water

3.0 QUALITY ASSURANCE PROJECT PLAN

This section presents the Quality Assurance Project Plan (QAPP) for groundwater monitoring at the Arrowwood Housing Sites at NSB New London. The QAPP discusses project objectives and QA/QC protocols to be used to achieve the DQOs.

3.1 DATA QUALITY OBJECTIVES

This section summarizes the DQOs for compliance monitoring at the Arrowwood Housing Sites.

3.1.1 Problem Definition/Background

The Arrowwood Housing Sites are located on Arrowwood Drive within the Nautilus Park housing area approximately 1 mile south of the NSB, to the east of Connecticut Route 12. These properties are the former site of several duplex residential dwellings for NSB personnel. The structures on the Arrowwood Housing Sites have been demolished as part of the redevelopment of this area, and new townhomes have been constructed on many of the properties.

Several of the properties on Arrowwood Drive have been impacted by releases of fuel oil from underground storage tanks (USTs). From May to July 2006, the Navy performed removal actions at 11 properties located on Arrowwood Drive. Removal activities included the excavation of petroleum-impacted soils until field screening indicated that the limits of the release area had been reached. The Navy collected confirmatory soil samples for laboratory analysis from the sidewalls and bottom (where practical) of the soil excavations and backfilled the excavations with clean material. A total of approximately 1,750 tons of petroleum impacted soils were removed and disposed during these removal actions (TtEC, 2006).

Groundwater was encountered during soil excavation at seven of the Arrowwood Drive properties. Groundwater (present as surface water at the bottom of soil excavation) samples were collected from these properties and analyzed for Extractable Total Petroleum Hydrocarbons (ETPH) during removal activities. At four of these properties, the concentration of ETPH detected in groundwater samples exceeded the Connecticut Department of Environmental Protection (CTDEP) GA/GAA Groundwater Protection Criteria (GWPC) of 500 ppb, which is the remediation goal for the site. Groundwater samples collected from these four properties did not exceed the CTDEP Residential Volatilization Criteria (VC) (TtEC, 2006).

As stated in Section 1.0, the purpose of the work outlined in this Work Plan is to complete four quarterly rounds of compliance monitoring at the Arrowwood Housing Sites to evaluate the effectiveness of the soil removal actions that were completed in 2006 at 47/49, 109/113, 122/124, and 191/195 Arrowwood Drive. Compliance groundwater monitoring is being performed in accordance with the Connecticut Remediation Standard Regulations (Regulations of the Connecticut State Agencies Section 22a-133k-1 through 3 and 22a-133q-1) (RSRs) Section 22a-133k-3(g)(3)(a). Groundwater and surface water samples will be collected, and the analytical results will be compared to applicable State standards. Recommendations for future monitoring will be made based on the results of compliance monitoring.

3.1.2 Decision Statement

Decision statements are summaries of decisions that have been developed to address the problem described in Section 3.1.1. Based on the problem definition described above, the following decision statement was identified: *To determine whether petroleum constituents are present in groundwater/surface water above background concentrations.* The outcome of this statement will determine the future requirements for groundwater monitoring at the four Arrowwood Housing Sites.

3.1.3 Inputs to the Decision

In order to resolve the decision statement discussed above, quarterly groundwater samples will be collected from 15 monitoring wells and analyzed for the presence of ETPH by the Connecticut Department of Public Health (DPH) ETPH Method and VOCs by EPA SW-846 Method 8260B. Analytical results will be compared to background concentrations, Connecticut GA GWPC, GA VC, and Connecticut Water Quality Standards (human health and aquatic life criteria) to address the decision statement.

3.1.4 Study Area Boundaries

The study area boundaries are limited to the 15 monitoring wells and one surface water sampling location depicted on Figures 2-1 through 2-4 of this Work Plan. Groundwater analytical results from each property will be evaluated independently to address the decision statements described in Section 3.1.2.

3.1.5 Decision Rules

The following decision rules were developed from the outputs of the first four DQO steps. Decision rules will be used as a guide to determine future groundwater monitoring requirements at the Arrowwood Housing Sites:

- If petroleum constituents (i.e. ETPH and VOCs) are not present in groundwater above background concentrations for four consecutive quarters of compliance monitoring, then 1 year of post-remediation monitoring will be performed.

- If petroleum constituents (i.e ETPH and VOCs) are present in groundwater above the laboratory detection limits but below the CTDEP GWPC for four consecutive quarters of compliance monitoring, then 3 years of post-remediation monitoring will be performed.

- If petroleum constituents (i.e. ETPH and VOCs) are present in groundwater above CTDEP GWPC during compliance monitoring, then additional monitoring is required to monitor natural attenuation or an alternative remedial action should be implemented

These evaluations will be made independently for each of the four Arrowwood Drive sites after each year of groundwater monitoring.

3.1.6 Decision Error Tolerances

Sampling results will be compared directly to CTDEP criteria on a well-by-well and parameter-by-parameter basis. The maximum concentration of each parameter detected in each well will be used to determine the outcome of the decision rules described in Section 3.1.5, except where duplicate sampling results are available. For duplicate results, the average of the two measurements will be compared to the applicable criterion.

3.2 MEASUREMENT/DATA ACQUISITION

This section describes the sampling design selected to achieve the objectives of the investigation. The sampling methods, handling, analytical requirements and methods, and QA/QC requirements are discussed. In addition, information about the instrumentation type, maintenance, calibration, and data management is also described.

3.2.1 Sampling Design

Sampling activities will be performed at the Arrowwood Housing Sites to determine if concentrations of ETPH and VOCs are present in groundwater above applicable State criteria. At each of four properties, a monitoring well network was installed to support groundwater monitoring consisting of one upgradient well, one well within the soil removal area, and one or more wells downgradient from the soil removal area.

3.2.2 Sampling Methods Requirements

Groundwater and surface water sample collection procedures, including sampling methods and equipment decontamination procedures, are discussed in Section 2.0 of this Work Plan.

3.2.3 Sample Handling and Custody Requirements

Custody of samples will be maintained at all times and documented in the chain-of-custody forms (Section 3.3.3). Chain of custody begins at the time the sample is collected and is maintained by storing the samples on ice in coolers that are locked or are sealed with a custody seal. The chain-of-custody forms are shipped to the laboratory with the samples.

Each sample collected will be assigned a unique sampling tracking number. The sample location identification system is described in Section 2.4. The system is based on TtNUS SOP CT-04 (Appendix B). The preferred sample location tracking number will consist of a four- to five-segment, alphanumeric code that identifies the site, sample medium, location, and sample depth (in case of soil samples). The sample containers, preservatives, and the maximum allowable sample holding times before sample extraction, digestion, or analysis are presented in Table 2-2.

3.2.4 Analytical Methods Requirements

A summary of analytical methods is presented in Table 2-1. The Tetra Tech analytical technical specification for this work will include the method of analysis, instrumentation, detection limits, QC criteria, corrective action measures, sampling schedules, sample numbers, communication contact, and delivery requirements.

3.2.5 Quality Control Requirements

The quality control procedures refer to both field and laboratory control operations. The results from analysis of field and laboratory QC samples are used to document data quality and to control the data acceptance within previously established check limits in order to meet the DQO requirements for the project.

The laboratory quality control procedures for analyses are included in the specific methods referenced in Table 2-1. Laboratory quality control criteria requirements will include laboratory blank acceptance, instrument calibration, initial and continuing calibration, instrument performance check, reagent standardization checks, laboratory precision requirements, and other analytical method-compliant QC results.

3.2.5.1 Standard Operating Procedures

This section describes the applicable Tetra Tech and U.S. EPA Region I SOPs to be utilized during long-term monitoring at the Arrowwood Housing Sites. These SOPs are included in Appendix B.

Tetra Tech SOPs:

- CT-05 - Database Records and Quality Assurance;
- SA-1.1 - Groundwater Sample Acquisition and Onsite Water Quality Testing;
- SA-6.1 - Non-Radiological Sample Handling;
- SA-6.3 - Field Documentation; and
- SA-7.1 - Decontamination of Field Equipment and Waste Handling.

EPA SOPs:

GW # 001 – Revision 2, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

3.2.5.2 Field Quality Control

In addition to periodic calibration of field equipment and appropriate documentation, quality control samples will be collected or generated during sampling activities. Quality control samples include field duplicates and blanks. Each type of field quality control sample is defined below.

Trip Blanks: Since VOC samples will be collected as part of this work, trip blanks are required in every cooler that is packed for shipping containing VOC samples.

Field Duplicates: Field duplicates will be submitted at the rate of one for every 10 samples per matrix. Field duplicates provide precision information regarding homogeneity and distribution of the contaminants; and measure the bias of sub-sampling.

3.2.6 Instrum nt/Equipment Te ting, Inspection, and Maintenance Requirements

Maintenance and calibration is the process of providing the degree of care necessary to obtain high-quality production, ensuring the optimum useful life of fieldwork equipment. The process includes determining the need for and performing preventative maintenance and rehabilitation.

Equipment, instruments, gauges, and other items requiring preventive maintenance will be serviced in accordance with the manufacturer's specified recommendations. The manufacturer's procedures identify the schedule for servicing critical items in order to ensure proper operations and to maximize the measurement system usability.

All equipment and instruments used during groundwater monitoring will be rented. For rental equipment and instruments used for the sampling activities, the rental firms will be responsible for the proper maintenance and repair of these items, and for tracking and documenting the equipment and instrument maintenance and service.

When equipment and instruments are in use in the field or at sites, routine maintenance may be required. Experienced field personnel will perform routine maintenance or service in accordance with the manufacturer's instructions. If the equipment or instrument cannot be serviced in the field, then these items will be returned to the manufacturer or the rental firm for proper service.

3.2.7 Instrument Calibration and Frequency

The equipment used for data collection, laboratory analysis, and health and safety monitoring is calibrated and maintained according to the manufacturer's instructions.

Monitoring instruments that will be used during the field investigation activities are listed below. The following instruments will be calibrated prior to daily use; calibration will be checked at the end of the day:

- Photoionization detector (PID);
- pH, ORP, temperature, specific conductance, turbidity measuring instruments for water quality.

During calibration, an appropriate maintenance check will be performed on each piece of equipment. If damaged or failed parts are identified during the daily maintenance check and it is determined that the damage could have an impact on the instrument's performance, the instrument will be removed from service until the identified parts are repaired or replaced.

Calibration is documented on an Equipment Calibration Log sheet, which is presented in Appendix A.

3.2.8 Inspection/Acceptance Requirements for Supplies and Consumables

Supplies and consumables will meet the requirements of the specific task. The Tetra Tech Equipment Manager and the FOL perform the inspection of consumables and supplies for use in the project.

3.3 DOCUMENTATION AND RECORDS

Documentation to be used in the field investigation is described below.

3.3.1 Site Log Book

A bound site logbook (notebook) will be maintained by the FOL. The FOL or designee will record all information related to sampling or field activities. This information will include sample time, weather conditions, unusual events, field measurements, and descriptions of photographs, etc. Additional field logbooks (notebooks) will be used to cover specific tasks; however, the site logbook will contain a summary of each day's activities, and will reference the other field notebooks and field forms when applicable. The requirements of the site logbook are outlined in SOP SA-6.3.

3.3.2 Sample Log Sheets

The field team will complete sample log sheets for all groundwater and surface water samples collected. The sample log sheet forms contain information about sample location, date, and time of the sample collection, as well as a groundwater quality parameters observed during purging. Sample log sheets are included in Appendix A.

3.3.3 Chain-Of-Custody Record and Custody Seal

The original chain-of-custody record is enclosed in plastic and secured to the inside lid of the sample cooler for shipment to the laboratory. If multiple coolers are required to ship a single set of samples, the chain-of-custody form will be included in the cooler labeled "cooler #1 of X" a copy of the chain of custody form is retained for the project files. Shipping coolers are secured with tape and two signed and dated custody seals are placed across the cooler opening. Copies of the chain of custody forms are contained in Appendix A.

The laboratory custodian receiving the samples signs and dates the chain-of-custody records to acknowledge receipt of the samples. The laboratory is then responsible for maintaining sample custody records and returning the original chain-of-custody form with the data analysis results.

3.4 DATA VALIDATION AND USABILITY

This section describes the data review, data verification, and data evaluation processes necessary to determine whether or not the data conform to the specified criteria satisfying the project objectives.

3.4.1 Data Review, Validation, and Verification Requirements

Tetra Tech will conduct a limited QC data review and validation of laboratory data. The limited review will be a modified Tier-II validation, and will not constitute a formal Tier level of validation as specified in the 1996 EPA Region I guidelines (see Appendix D). The modified Tier II-like data validation will be conducted according to the procedures listed in Section 3.4.2

3.4.2 Validation and Verification Methods

The modified Tier II-like data validation includes checking chain-of-custody records for sampling, shipping, analysis, and reporting for accuracy and completeness. The following data validation worksheets for organic and inorganic analysis will be completed:

- Completeness assessment;
- Sample preservation and holding times (VOC);
- GC/MS instrument performance check;
- Initial and continuing calibration, blank analysis (VOC);
- Surrogate spike recoveries;
- Internal standard performance (VOC);
- Field duplicate precision
- Matrix Spike/Matrix Spike Duplicates

The summary table data will be qualified as a result of the Tier II-like validation. The qualified summary table will be attached to the letter report.

3.4.3 Rec nciliation and Data Quality Objectives

The results obtained from the project will be reconciled with the DQOs to satisfy the goals for precision, accuracy, representativeness, and data completeness. Assessment of data representativeness will include an evaluation of the sample data's representativeness of conditions at the location the sample was collected, and of the Site as a whole.

Limitations on the use of laboratory or field data will be communicated to the TtNUS Project Manager and other data users. This communication will include incorporating the results of the precision, accuracy, representativeness, and data completeness assessments, (including all tables generated to assess the precision and accuracy of the data), into the final report. Explanations and conclusions regarding the quality and usefulness of the data, and any limitations of data use which were drawn from the precision, accuracy, representativeness, and data completeness assessments will also be included in the final report. Re-analysis or new sampling of the locations/samples affected might be required when critical data results do not meet the established DQOs.

4.0 REPORTING

After completion of the four quarterly rounds of sampling, a Monitoring Report summarizing the results of groundwater and surface water sampling activities will be created. The Monitoring Report will consist of the following:

- Introduction with a description of the subject properties, including a field sketch depicting the current conditions at each property;
- A narrative summary of all sampling activities and waste disposal procedures;
- A tabular summary of analytical data, including a comparison of sampling results to the applicable remedial goals;
- An evaluation of quality control (QC) sampling results;
- Conclusions based on the data collected during the four sampling rounds, with recommendations for future action based on the requirements of Connecticut regulations; and
- Appendices including groundwater level measurement forms, low-flow sample collection log sheets, surface water sampling log sheets, laboratory chain-of-custody forms, and full laboratory reports.

TABLES

TABLE 2-1

GROUNDWATER/SURFACE WATER SAMPLE SUMMARY
ARROWWOOD HOUSING SITES – NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

Parameter	Method	Matrix	Field Samples	Field Duplicates(1)	Trip Blanks(2)	Total Samples(2)	Lab QC Samples
GROUNDWATER							
VOCs	SW-846 8260B(3)	GW	15	2	3	20	1
ETPH	CTDEP(4)	GW	15	2	0	17	1
SURFACE WATER							
VOCs	SW-846 8260B(3)	SW	1	1	1	3	0
ETPH	CTDEP(4)	SW	1	1	0	2	0

Notes:

1. Field duplicate samples will be collected at a rate of 1 per 10 samples.
2. One trip blank will be sent in each cooler containing VOC and/or ETPH samples or at a rate of 1 per 20 samples, whichever is greater. The total number of VOC and ETPH samples will depend on the number of coolers sent during the entire sampling event due to the trip blanks.
3. EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.*
4. ETPH by CTDEP Method for analysis of Extractable Total Petroleum Hydrocarbons.

TABLE 2-2

SAMPLE CONTAINER, PRESERVATION, AND HOLDING TIME REQUIREMENTS
ARROWWOOD HOUSING SITES – NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

Matrix	Analysis	Containers Per Sample[1]	Container Type [2]	Preservative	Max. Holding Time [3]
Groundwater/Surface Water (aqueous)	VOCs	2	40-ml amber vial with Teflon septa cap	4°C; HCL to pH<2	14 days
	ETPH	2	1-liter amber glass with Teflon lined lid	4°C; 5ml of 1:1 HCL	14 days extraction 40 days analysis

Notes:

1. Triple volume of groundwater samples should be collected for VOC and ETPH analysis at the rate of 1 per 20 samples for laboratory analysis, as per Section 2.5.
2. Sample containers shall meet specifications delineated in EPA OSWER Directive No. 9240.0-05A.
3. Maximum holding time from date of sample collection to date of sample extraction or analysis is based on analyte with shortest holding time.

TABLE 2-3

ETPH AND VOC TARGET ANALYTES – GROUNDWATER
ARROWWOOD HOUSING SITES – NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

Analytes	CAS Number	RSR GWPC[1] (µg/L)	RSR Res. VC[2] (µg/L)	Practical Quantitation Limit (µg/L)	Method Detection Limits (µg/L)
Extractable TPH (CTDEP Method)					
ETPH	NA	100	NA	75	44.9
Volatile Organic Compounds (Method 8260B)					
Benzene	71-43-2	1	215	1	0.39
Ethylbenzene	100-41-4	700	50,000	1	0.40
Isopropylbenzene	98-82-8	NA	NA	1	0.61
Methyl tert-Butyl Ether	1634-04-4	100	50,000	1	0.30
Naphthalene	91-20-3	280	NA	1	0.35
Toluene	108-88-3	1,000	23,500	1	0.50
Total Xylenes	1330-20-7	530	21,300	3	1.26

Not s:

NA Not applicable
(1) Connecticut Remediation Standard Regulations Groundwater Protection Criteria
(2) Connecticut Remediation Standard Regulations GAA Volatilization Criteria

TABLE 2-4

ETPH/VOC TARGET ANALYTES – SURFACE WATER
ARROWWOOD HOUSING SITES – NAVAL SUBMARINE BASE NEW LONDON
GROTON, CONNECTICUT

Analytes	CAS Number	Aquatic Life Criteria, Freshwater Acute (µg/L)	Aquatic Life Criteria, Freshwater Chronic (µg/L)	HH Criteria, Consumption of Organisms (µg/L)	HH Criteria, Consumption of Water and Organisms (µg/L)	Practical Quantitation Limit (µg/L)	Achievabl Laboratory Limits QLs (µg/L)
Extractable TPH (CTDEP Method)							
ETPH	NA	NA	NA	NA	NA	75	44.9
Volatile Organic Compounds (Method 8260B)							
Benzene	71-43-2	NA	NA	71	1.2	1	0.39
Ethylbenzene	100-41-4	NA	NA	29,000	700	1	0.40
Isopropylbenzene	98-82-8	NA	NA	NA	NA	1	0.61
Methyl tert-Butyl Ether	1634-04-4	NA	NA	NA	NA	1	0.30
Naphthalene	91-20-3	NA	NA	20,513	677	1	0.35
Toluene	108-88-3	NA	NA	200,000	1,000	1	0.50
Total Xylenes	1330-20-7	NA	NA	NA	NA	3	1.26

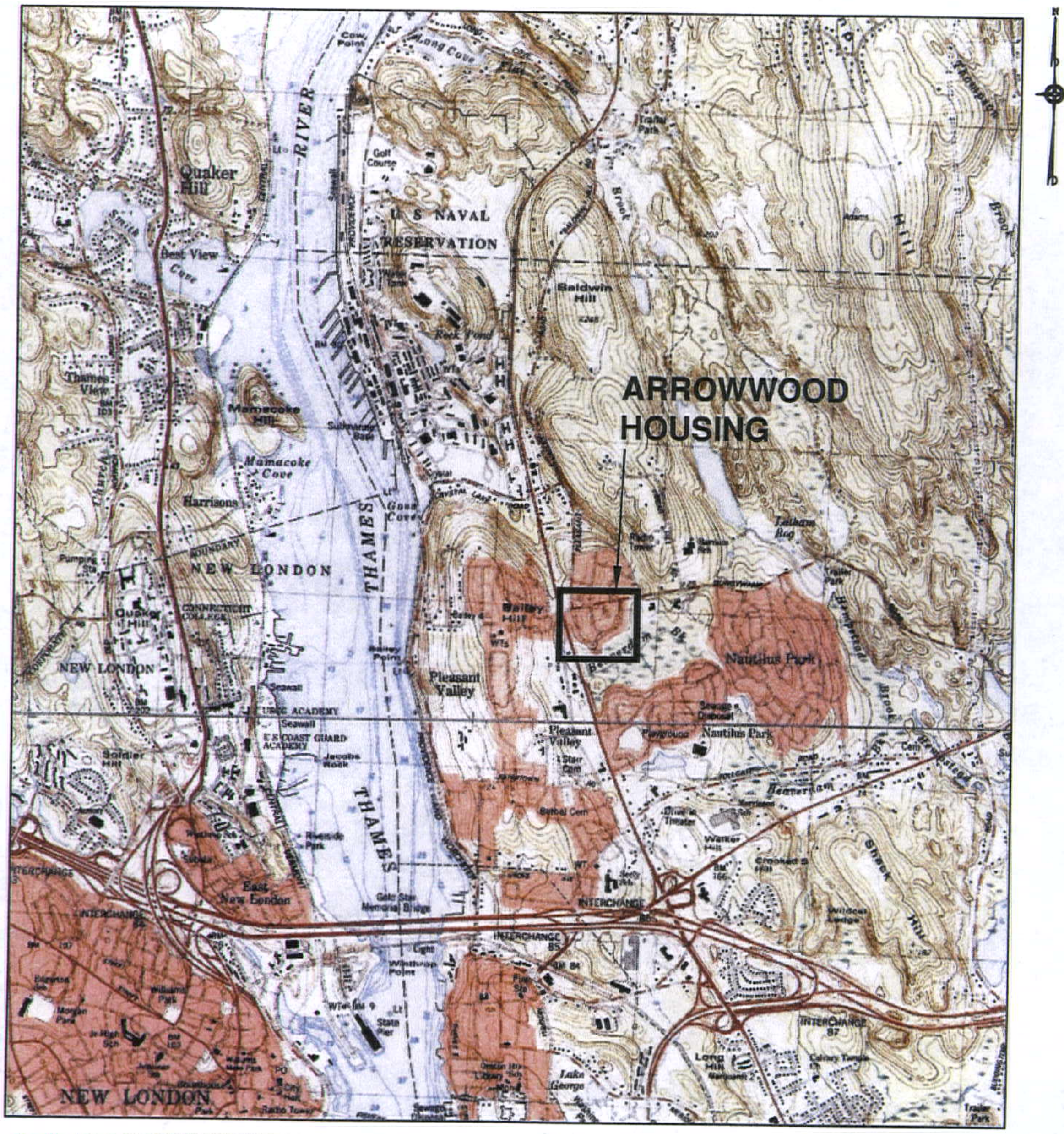
Not s:

NA Not applicable

(1) Criteria from CTDEP *Water Quality Standards*, Surface Water Quality Standards effective December 17, 2002.

FIGURES

ACAD: \00869\0211\LOCUS.DWG 07/16/07 DWM



BASEMAP: PORTIONS OF THE FOLLOWING U.S.G.S. QUADRANGLE MAPS: NEW LONDON, CONN.–N.Y., 1984 AND UNCASVILLE, CONN., 1984

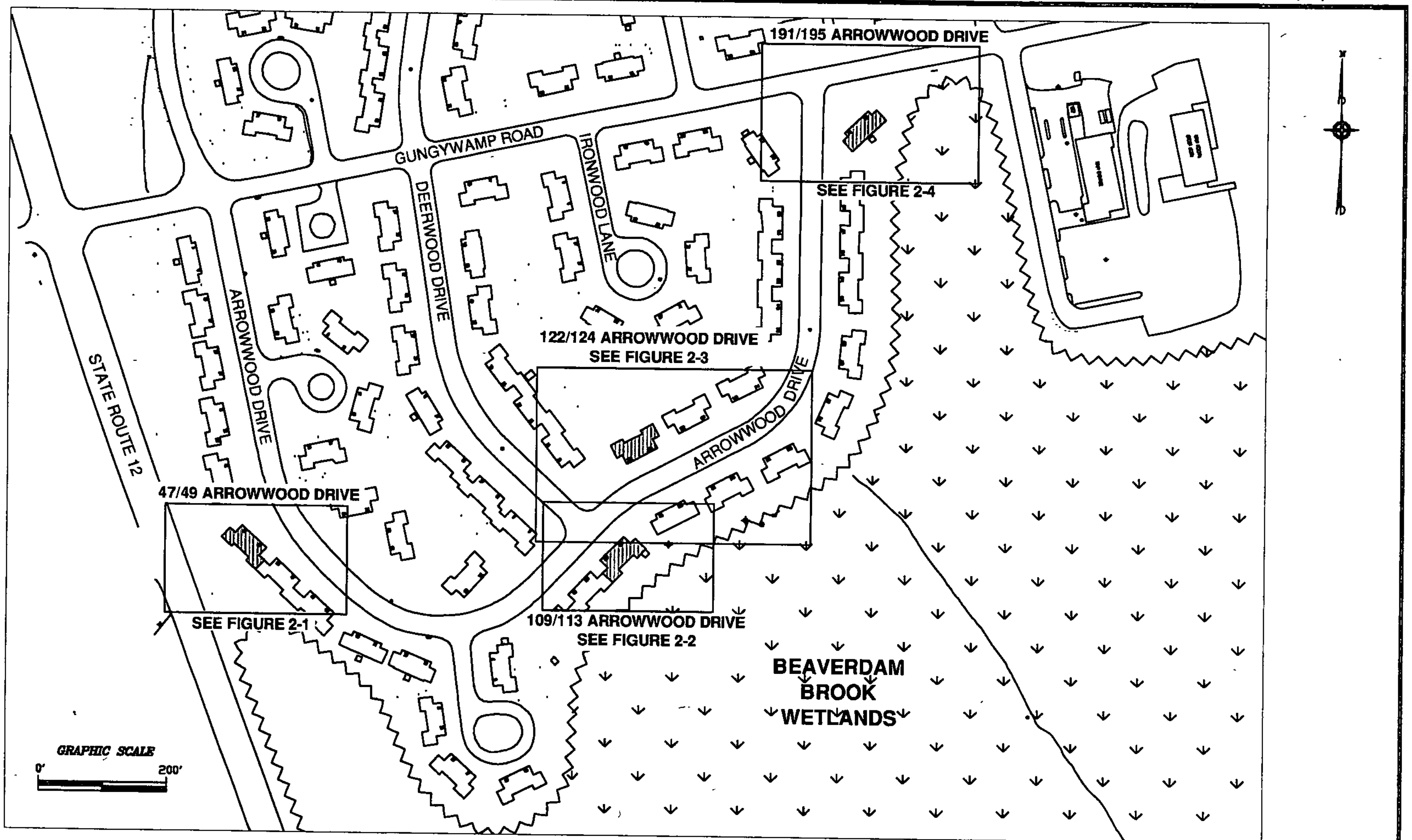
GRAPHIC SCALE

0 0.5 MILE 1 MILE

QUADRANGLE LOCATION

TETRA TECH, INC.	SITE LOCUS NAVAL SUBMARINE BASE NEW LONDON GROTON, CONNECTICUT	SCALE AS NOTED FILE \00869\0211\LOCUS.DWG REV 0 DATE 07/16/07 FIGURE NUMBER 1-1

ACAD: 00869\0211\NP.DWG 07/16/07 DWM



LEGEND

TREE LINE (APPROXIMATE)

WETLAND (APPROXIMATE)

TETRA TECH, INC.

FORMER ARROWWOOD DRIVE HOUSING PLAN

NAVAL SUBMARINE BASE NEW LONDON

GROTON, CONNECTICUT

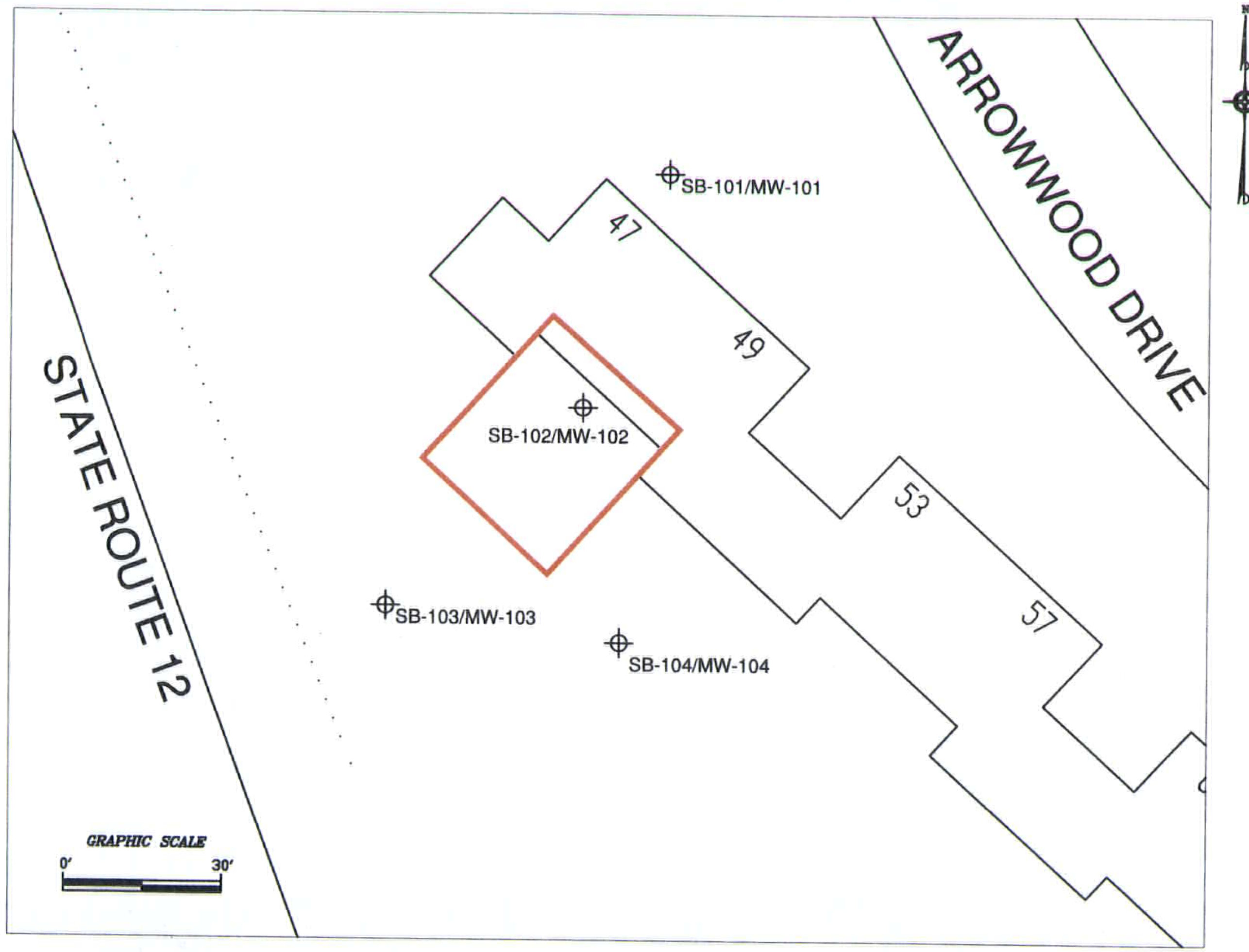
SCALE	AS NOTED
FILE	00869\0211\NP.DWG
REV 0	DATE 07/16/07
FIGURE NUMBER	1-2

ACAD: 00869\0211\NP.DWG 10/30/07 DWM

LEGEND

LIMITS OF JUNE 2006 SOIL EXCAVATION

PROPOSED MONITORING WELL LOCATION



NOTES:

1. BASE MAP PROVIDED BY NSB NEW LONDON
2. EXCAVATION LIMITS FROM DRAFT PROJECT CLOSEOUT REPORT FOR HOUSING UST REMEDIATION (TtEC, 2006)

TETRA TECH, INC.

FORMER 47/49 ARROWWOOD DRIVE

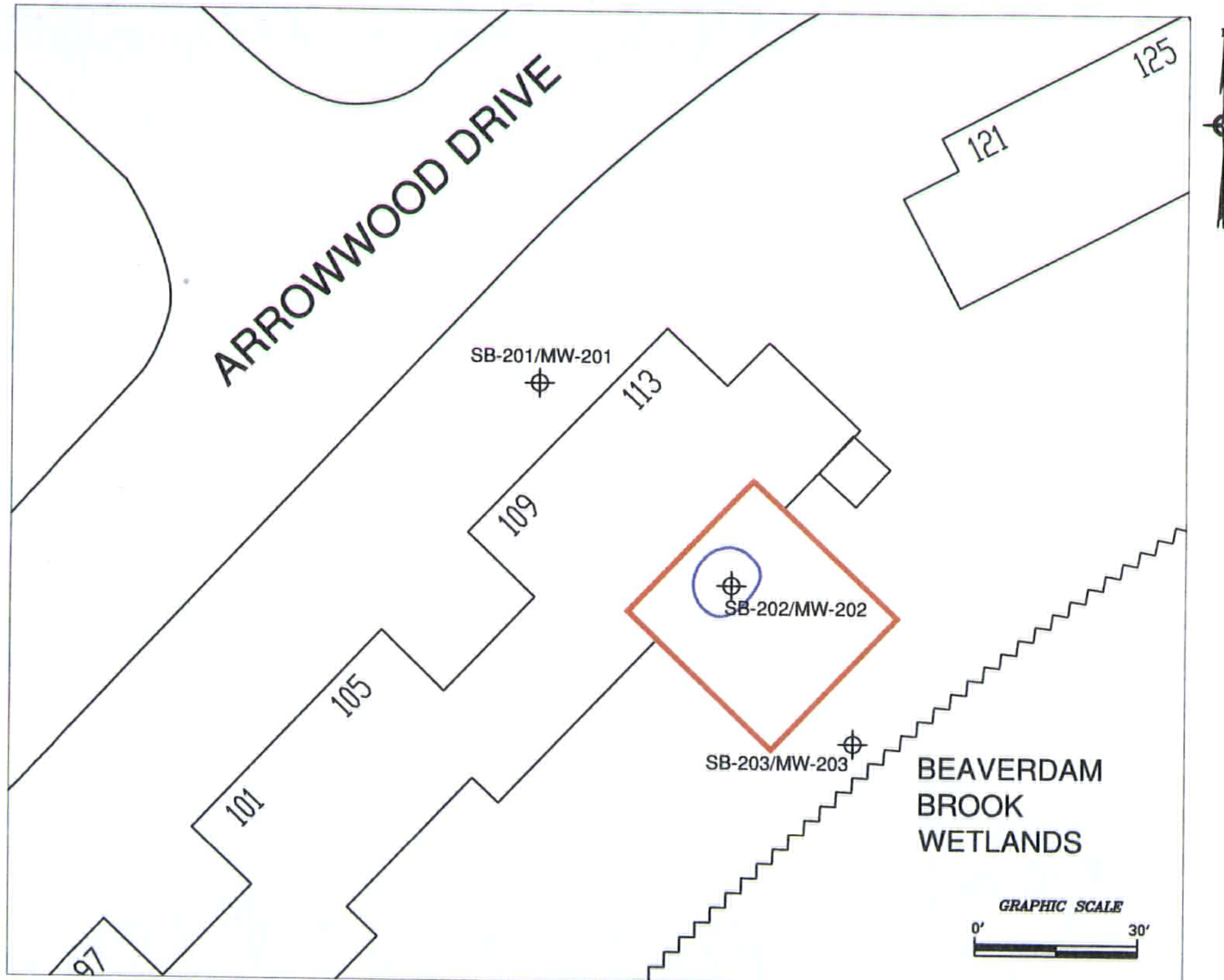
NAVAL SUBMARINE BASE NEW LONDON

GROTON, CONNECTICUT

SCALE	AS NOTED
FILE	00869\0211\NP.DWG
REV 0	DATE 10/30/07
FIGURE NUMBER	2-1

LEGEND

- LIMITS OF MAY 2006 SOIL EXCAVATION
- FORMER UST LOCATION
- TREE LINE (APPROXIMATE)
- PROPOSED MONITORING WELL LOCATION



NOTES:

1. BASE MAP PROVIDED BY NSB NEW LONDON
2. EXCAVATION LIMITS FROM DRAFT PROJECT CLOSEOUT REPORT FOR HOUSING UST REMEDIATION (TtEC, 2006)

TETRA TECH, INC.

FORMER 109/113 ARROWWOOD DRIVE

NAVAL SUBMARINE BASE NEW LONDON

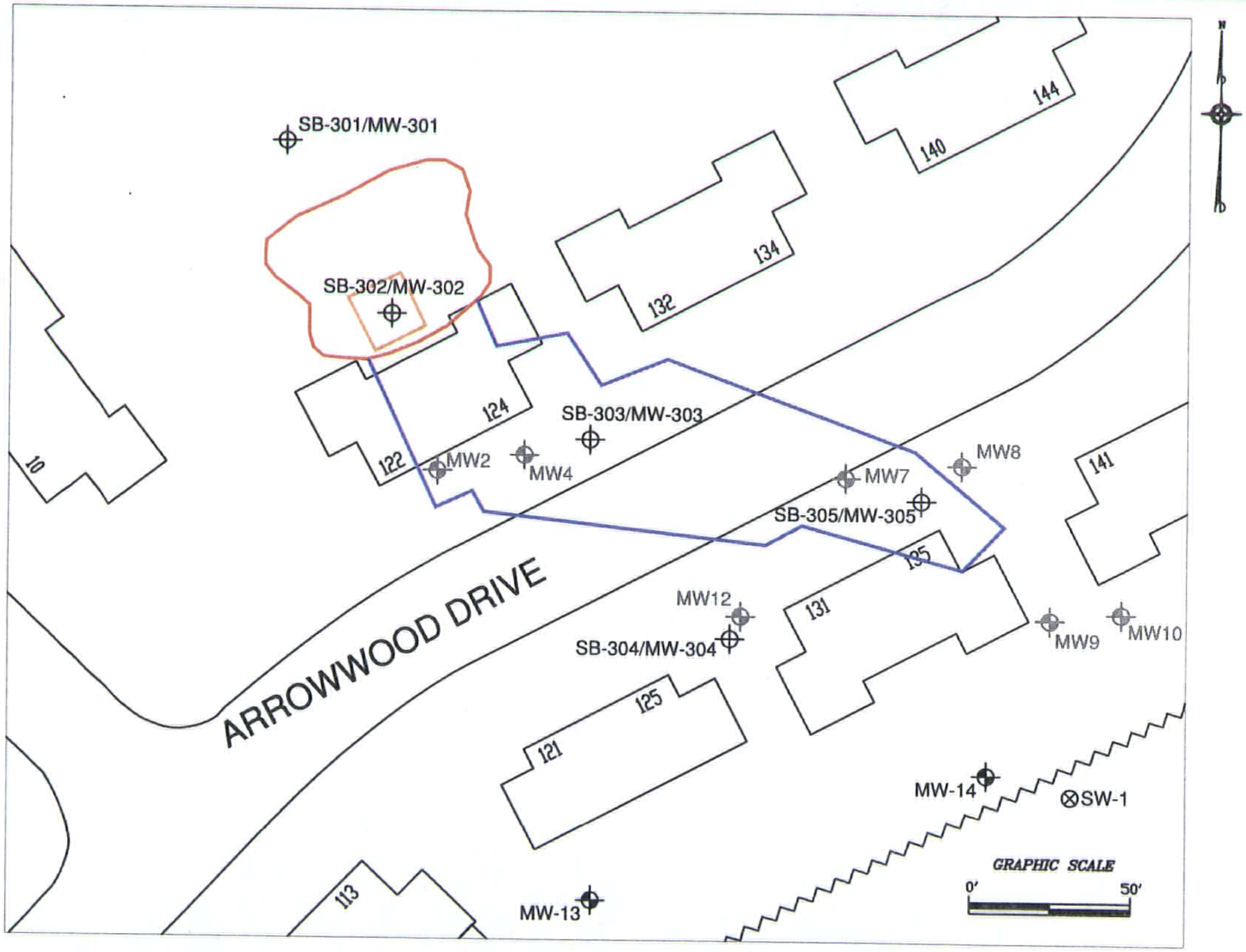
GROTON, CONNECTICUT

SCALE	AS NOTED
FILE	00869\0211\NP.DWG
REV	0
DATE	09/04/07
FIGURE NUMBER	2–2

ACAD: 00869\0211\NP.DWG 09/04/07 DWM

LEGEND

- LIMITS OF 2002 SOIL EXCAVATION
- LIMITS OF MAY 2006 SOIL EXCAVATION
- FORMER UST LOCATION
- TREE LINE (APPROXIMATE)
- PROPOSED MONITORING WELL LOCATION
- EXISTING MONITORING WELL LOCATION
- EXISTING SURFACE WATER SAMPLING LOCATION
- FORMER MONITORING WELL LOCATION



NOTES:

1. BASE MAP PROVIDED BY NSB NEW LONDON
2. EXCAVATION LIMITS FROM DRAFT PROJECT CLOSEOUT REPORT FOR HOUSING UST REMEDIATION (TtEC, 2006)

TETRA TECH, INC.

FORMER 122/124 ARROWWOOD DRIVE

NAVAL SUBMARINE BASE NEW LONDON

GROTON, CONNECTICUT

SCALE	AS NOTED
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REV	0
DATE	09/04/07
FIGURE NUMBER	2-3

ACAD: 00869\0211\NP.DWG 09/04/07 DWM

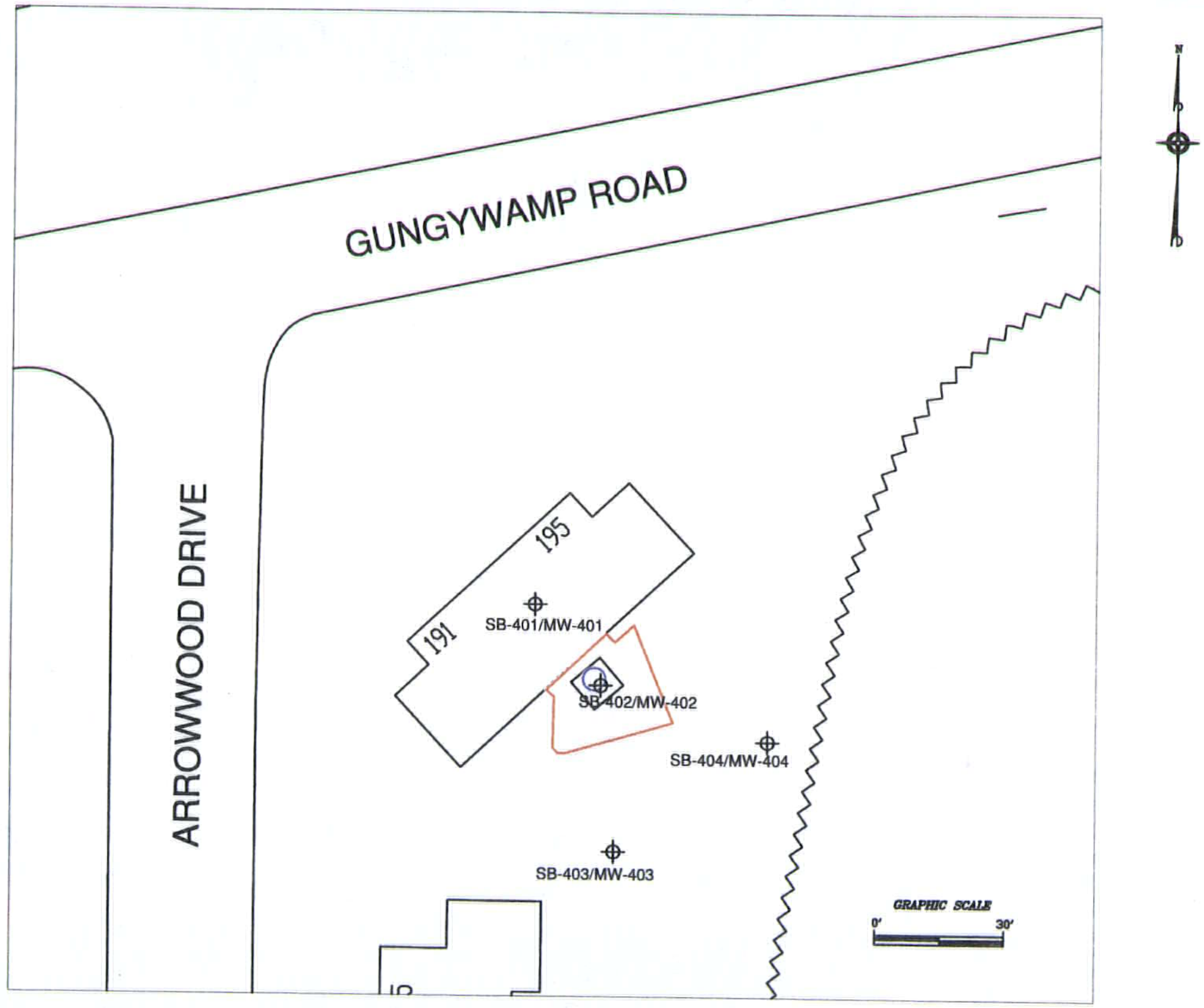
LEGEND

LIMITS OF MAY 2006 SOIL EXCAVATION

FORMER UST LOCATION

TREE LINE (APPROXIMATE)

PROPOSED MONITORING WELL LOCATION



NOTES:

1. BASE MAP PROVIDED BY NSB NEW LONDON
2. EXCAVATION LIMITS FROM DRAFT PROJECT CLOSEOUT REPORT FOR HOUSING UST REMEDIATION (TtEC, 2006)

TETRA TECH, INC.

FORMER 191/195 ARROWWOOD DRIVE

NAVAL SUBMARINE BASE NEW LONDON

GROTON, CONNECTICUT

SCALE	AS NOTED
FILE	00869\0211\NP.DWG
REV 0	DATE 09/04/07
FIGURE NUMBER	2-4

REFERENCES

REFERENCES

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APPENDIX A

FIELD FORMS

BORING LOG FOR

PROJECT NO.:

LOGGED BY:

DRILLED BY (Company/Driller):

GRD. SURFACE ELEVATION:

TRANSCRIBED BY:

ELEVATION FROM:

BORING NO.:

START DATE.

COMPLETION: DATE:

MON. WELL NO.:

CHECKED BY:

DEPTH (FEET)	BLOWS PER 6"	SAMP REC. / SAMP LENG.	SAMPLING TIME & SAMPLE NO (QA/QC STATUS)	DEPTH MAT'L CHG / WELL PROF'L	SOIL DENSITY/ CONSIS. or ROCK HARD.	CLR	MATERIAL CLASSIFICATION	USCS or ROCK BRKN	REMARKS (moisture condition; odors; geological classification; rock weathering; etc.)	FIELD SCREENING DATA *METHOD* = [FID, (PPM)]
		/								
		/								
		/								
		/								
		/								
		/								
		/								
		/								

TYPE OF DRILLING RIG:

METHOD OF ADVANCING BORING:

METHOD OF SOIL SAMPLING:

METHOD OF ROCK CORING:

GROUNDWATER LEVELS:

OTHER OBSERVATIONS:

BORING NO.:

Tetra Tech NUS, Inc.

PAGE: OF

TtNUS Form 0018

FLUSH MOUNT MONITORING WELL CONSTRUCTION LOG

TETRA TECH NUS INC.

PROJECT NAME: ______ PROJECT NO: ______

PROJECT LOCATION: ______ WELL NO: ______

CLIENT: ______ BORING NO: ______

CONTRACTOR: ______ DRILLER: ______ BORING LOCATION: ______

LOGGED BY: ______ DATE: ______

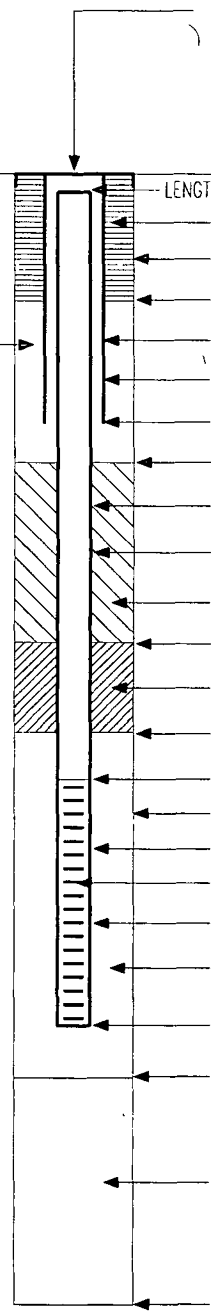
CHECKED BY: ______ DATE: ______

PAGE 1 OF

FLUSH MOUNT PROTECTIVE CASING

GROUND ELEVATION

SAND DRAIN LAYER



- LENGTH RISER PIPE BELOW GRD. SURF (Ft.) ______
- TYPE OF SURFACE SEAL ______
- DIA. SURFACE SEAL BGS (In) ______
- DEPTH TO BOTTOM OF SURFACE SEAL (Ft) ______
- I.D. OF PROTECTIVE CASING (In) ______
- TYPE OF PROTECTIVE CASING ______
- DEPTH BOTTOM OF PROTECTIVE CASING (Ft.) ______
- DEPTH BOTTOM OF DRAIN LAYER (Ft.) ______
- RISER PIPE (In) I.D.: ______ O.D. ______
- TYPE OF RISER PIPE ______
- TYPE OF BACKFILL AROUND RISER PIPE ______
- DEPTH TOP OF SEAL (Ft) ______
- TYPE OF SEAL ______
- DEPTH BOTTOM OF SEAL (Ft) ______
- DEPTH TOP OF PERVIOUS SECTION (Ft.) ______
- DIAMETER OF BOREHOLE (In.) ______
- TYPE OF PERVIOUS SECTION ______
- TYPE OF OPENINGS ______
- PERVIOUS SECTION (In) I.D.: ______ O.D.: ______
- TYPE OF FILTER PACK AROUND PERVIOUS SECTION ______
- DEPTH BOTTOM OF PERVIOUS SECTION (Ft) ______
- DEPTH BOTTOM OF FILTER PACK (Ft.) ______
- TYPE OF BACKFILL (GROUT) BELOW FILTER PACK ______
- END OF BORING ______

GENERAL NOTE:

1 Entry of 0.00 for Ground Elevation Indicates that Surveyed Ground Elevation is NOT Available

APPENDIX B

STANDARD OPERATING PROCEDURES

TETRA TECH NUS, INC.	**STANDARD OPERATING PROCEDURES**	Number: CT-04	Page: 1 of 6
		Effective Date: 09/03	Revision: 1
		Applicability: Tetra Tech NUS, Inc.	
		Prepared: Risk Assessment Department	
Subject: SAMPLE NOMENCLATURE		Approved: D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this document is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix.
- Sorting of data by depth.
- Maintenance of consistency (field, laboratory, and data base sample numbers).
- Accommodation of all project-specific requirements.
- Accommodation of laboratory sample number length constraints (maximum of 20 characters).

2.0 SCOPE

The methods described in this procedure shall be used consistently for all projects requiring electronic data.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES

Program Manager - It shall be the responsibility of the Program Manager (or designee) to inform contract-specific Project Managers of the existence and requirements of this Standard Operating Procedure.

Project Manager - It shall be the responsibility of the Project Manager to determine the applicability of this Standard Operating Procedure based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the sample nomenclature is thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and is consistent with this Standard Operating Procedure if relevant. It shall be the responsibility of the project manager to ensure that the Field Operations Leader is familiar with the sample nomenclature system.

Field Operations Leader - It shall be the responsibility of the Field Operations Leader to ensure that all field technicians or sampling personnel are thoroughly familiar with this Standard Operating Procedure and the project-specific sample nomenclature system. It shall be the responsibility of the Field Operations Leader to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

5.0 PROCEDURES

5.1 Introduction

The sample identification (ID) system can consist of as few as 8 but not more than 20 distinct alpha-numeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the lab has three segments and shall be as follows where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

(1) Soil and Sediment Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NNNN 4-Characters
Site Identifier	Sample Type	Sample Location	Sample Depth

(2) Aqueous (groundwater or surface water) Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	NN 2-Characters	-A
Site Identifier	Sample type	Sample Location	Round Number	Filtered Sample only

(3) Biota Sample ID

A or N 3- or 4-Characters	AAA 2- or 3-Characters	A or N 3- to 6-Characters	AA 2-Characters	NNN 3-Characters
Site Identifier	Sample Type	Sample Location	Species Identifier	Sample Group Number

5.2 Sample Identification Field Requirements

The various fields in the sample ID will include but are not limited to the following:

- Site Identifier
- Sample Type
- Sample Location
- Sample Depth
- Sampling Round Number
- Filtered
- Species Identifier
- Sample Group Number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary since many facilities/sites have multiple individual sites, SWMUs, operable units, etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six-characters (alpha, numeric, or a mixture). The six-characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to three-characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet, boring log, logbook, etc.

A two-digit round number will be used to track the number of aqueous samples taken from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001 and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 Example Sample Field Designations

Examples of each of the fields are as follows:

Site Identifier - Examples of site numbers/designations are as follows:

A01 - Area of Concern Number 1
125 - Solid Waste Management Unit Number 125
000 - Base or Facility Wide Sample (e.g., upgradient well)
BBG - Base Background

The examples cited are only suggestions. Each Project Manager (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample Type - Examples of sample types are as follows:

AH - Ash Sample
AS - Air Sample
BM - Building Material Sample
BSB - Biota Sample Full Body
BSF - Biota Sample Fillet
CP - Composite Sample
CS - Chip Sample
DS - Drum Sample
DU - Dust Sample
FP - Free Product
IDW - Investigation Derived Waste Sample
LT - Leachate Sample
MW - Monitoring Well Groundwater Sample
OF - Outfall Sample
RW - Residential Well Sample
SB - Soil Boring Sample
SD - Sediment Sample
SC - Scrape Sample

SG - Soil Gas Sample
SL - Sludge Sample
SP - Seep Sample
SS - Surface Soil Sample
ST - Storm Sewer Water Sample
SW - Surface Water Sample
TP - Test Pit Sample
TW - Temporary Well Sample
WC - Well Construction Material Sample
WP - Wipe Sample
WS - Waste/Solid Sample
WW - Wastewater Sample

Sample Location - Examples of the location field are as follows:

001 - Monitoring Well 1
N32E92 - Grid location 32 North and 92 East
D096 - Investigation derived waste drum number 96

Species Identifier - Examples of species identifier are as follows:

BC - Blue Crab
GB - Blue Gill
CO - Corn
SB - Soybean

5.4 Examples of Sample Nomenclature

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full body analysis the first time a minnow trap was checked at grid location A25 of SWMU 1415 three small blue gills were captured, collected and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415) the sample ID designation given was 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash "-F".

5.5 Field Quality Assurance/Quality Control (QA/QC) Sample Nomenclature)

Field QA/QC will be designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC Type	Date	Sequence Number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
RB = Rinsate Blank (Equipment Blank)
FD = Field Duplicate
AB = Ambient Conditions Blank
WB = Source Water Blank

The sampling time recorded on the Chain-of-Custody Form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log sheet (see SOP on Field Documentation).

5.6 Examples of Field QA/QC Sample Nomenclature

The first duplicate of the day for a filtered ground water sample collected on June 3, 2000 would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003 would be designated as FD11170303.

The first trip blank associated with samples collected on October 12, 2000 would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001 would be designated as RB11170101.

6.0 DEVIATIONS

Any deviation from this SOP must be addressed in detail in the site specific planning documents.

TETRA TECH NUS, INC.	**STANDARD OPERATING PROCEDURES**	Number CT-05	Page 1 of 7
		Effective Date 01/29/01	Revision 2
		Applicability Tetra Tech NUS, Inc.	
		Prepared Management Information Systems Department	
Subject DATABASE RECORDS AND QUALITY ASSURANCE		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this document is to specify a consistent procedure for the quality assurance review of electronic and hard copy databases. This SOP outlines the requirements for establishment of a Database Record File, Quality Assurance review procedures, and documentation of the Quality Assurance Review Process.

2.0 SCOPE

The methods described in this Standard Operating Procedure (SOP) shall be used consistently for all projects managed by Tetra Tech NUS (TtNUS).

3.0 GLOSSARY

Chain-of-Custody Form - A Chain-of-Custody Form is a printed form that accompanies a sample or a group of samples from the time of sample collection to the laboratory. The Chain-of-Custody Form is retained with the samples during transfer of samples from one custodian to another. The Chain-of-Custody Form is a controlled document that becomes part of the permanent project file. Chain-of-Custody and field documentation requirements are addressed in SOP SA-6.1.

Electronic Database - A database provided on a compact laser disk (CD). Such electronic databases will generally be prepared using public domain software such as DBase, RBase, Oracle, Visual FoxPro, Microsoft Access, Paradox, etc.

Hardcopy Database - A printed copy of a database prepared using the software discussed under the definition of an electronic database.

Form I - A printed copy of the analytical results for each sample.

Sample Tracking Summary - A printed record of sample information including the date the samples were collected, the number of samples collected, the sample matrix, the laboratory to which the samples were shipped, the associated analytical requirements for the samples, the date the analytical data were received from the laboratory, and the date that validation of the sample data was completed.

4.0 RESPONSIBILITIES

Database Records Custodian - It shall be the responsibility of the Database Records Custodian to update and file the Sample Tracking Summaries for all active projects on a weekly basis. It shall be the responsibility of the Database Records Custodian to ensure that the most recent copies of the Sample Tracking Summaries are placed in the Database Records file. It shall be the responsibility of the Database Records Custodian to ensure that a copy of all validation deliverables is provided to the Project Manager (for placement in the project file). It shall be the responsibility of the Database Records Custodian to ensure that photocopies of all validation deliverables and historical data and reports (as applicable) are placed in the Database Records file.

Data Validation Coordinator - It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that the Sample Tracking Summaries are maintained by the Database Records Custodian. It shall be the responsibility of the Data Validation Coordinator (or designee) to ensure that photocopies of all data validation deliverables are placed in the applicable Database Records file by the Database Records Custodian.

Earth Sciences Department Manager - It shall be the responsibility of the Earth Sciences Department Manager (or equivalent) to ensure that all field personnel are familiar with the requirements of this Standard Operating Procedure (specifically Section 5.5).

FOL - It shall be the responsibility of the FOL (FOL) of each project to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP, specifically regarding provision of the Chain-of-Custody Forms to the Database Records Custodian. Other responsibilities of the FOL are described in Sections 5.4 and 5.5.

Management Information Systems (MIS) Manager - It shall be the responsibility of the MIS Manager to ensure that copies of original electronic deliverables (CDs) are placed in both the project files and the Database Records File. It shall be the responsibility of the MIS Manager (or designee) to verify the completeness of the database (presence of all samples) in both electronic and hardcopy form in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that Quality Assurance Reviews are completed and are attested to by Quality Assurance Reviewers. It shall be the responsibility of the MIS Manager to ensure that records of the Quality Assurance review process are placed in the Database Records File. It shall be the responsibility of the MIS Manager to ensure that both electronic and hardcopy forms of the final database are placed in both the project and the Database Record File. It shall be the responsibility of the MIS Manager to ensure that data validation qualifiers are entered in the database.

Furthermore, it shall be the responsibility of the MIS Manager to participate in project planning at the request of the Project Manager, specifically with respect to the generation of level of effort and schedule estimates. To support the project planning effort, the MIS Manager shall provide a copy of the MIS Request From included as Attachment A to the project manager. It shall be the responsibility of the MIS Manager to generate level of effort and budget estimates at the time database support is requested if a budget does not exist at the time of the request. The MIS Request Form shall be provided to the Project Manager at the time of any such requests. It shall be the responsibility of the MIS Manager to notify the Project Manager of any anticipated level of effort overruns or schedule noncompliances as soon as such problems arise along with full justification for any deviations from the budget estimates (provided they were generated by the MIS Manager). It shall be the responsibility of the MIS Manager to document any changes to the scope of work dictated by the Project Manager, along with an estimate of the impact of the change on the level of effort and the schedule.

Program/Department Managers - It shall be the responsibility of the Department and/or Program Managers (or designees) to inform their respective department's Project Managers of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of each Project Manager to determine the applicability of this SOP based on: (1) program-specific requirements, and (2) project size and objectives. It shall be the responsibility of the Project Manager (or designee) to ensure that the FOL is familiar with the requirements regarding Chain-of-Custody Form provision to the Database Records Custodian. It shall be the responsibility of the Project Manager (or designee) to determine which, if any, historical data are relevant and to ensure that such data (including all relevant information such as originating entity, sample locations, sampling dates, etc.) are provided to the Database Records Custodian for inclusion in the Database Records File. It shall be the responsibility of the Project Manager to obtain project planning input regarding the level of effort and schedule from the MIS Manager. It shall be the responsibility of the Project Manager to complete the database checklist (Attachment A) to support the level of effort and schedule estimate and to facilitate database preparation and subroutine execution.

Risk Assessment Department Manager - It shall be the responsibility of the Risk Assessment Department Manager to monitor compliance with this Standard Operating Procedure, to modify this SOP as necessary, and to take corrective action if necessary. Monitoring of the process shall be completed on a quarterly basis.

Quality Assurance Reviewers - It shall be the responsibility of the Quality Assurance Reviewers to verify the completeness of the sample results via review of the Chain-of-Custody Forms and Sample Tracking Summaries. It shall be the responsibility of the Quality Assurance Reviewers to ensure the correctness of the database via direct comparison of the hardcopy printout of the database and the hardcopy summaries of the original analytical data (e.g., Form Is provided in data validation deliverables). Correctness includes the presence of all relevant sample information (all sample information fields), agreement of the laboratory and database analytical results, and the presence of data validation qualifiers.

Quality Manager - It shall be the responsibility of the Quality Manager to monitor compliance with this Standard Operating Procedure via routine audits.

5.0 PROCEDURES

5.1 Introduction

Verification of the accuracy and completeness of an electronic database can only be accomplished via comparison of a hardcopy of the database with hardcopy of all relevant sample information. The primary purposes of this SOP are to ensure that 1) all necessary hardcopy information is readily available to Quality Assurance Reviewers; 2) ensure that the Quality Assurance review is completed in a consistent and comprehensive manner, and; 3) ensure that documentation of the Quality Assurance review process is maintained in the project file.

5.2 File Establishment

A Database Record file shall be established for a specific project at the discretion of the Project Manager. Initiation of the filing procedure will commence upon receipt of the first set of Chain-of-Custody documents from a FOL or sampling technician. The Database Record Custodian shall establish a project-specific file for placement in the Database Record File. Each file in the Database Record File shall consist of standard components placed in the file as the project progresses. Each file shall be clearly labeled with the project number, which shall be placed on the front of the file drawer and on each and every hanging file folder relevant to the project. The following constitute the minimum components of a completed file:

- Electronic Deliverables
- Sample Tracking Forms
- Chain-of-Custody Forms
- Data Validation Letters
- Quality Assurance Records

5.3 Electronic Deliverables

The format of electronic deliverables shall be specified in the laboratory procurement specification and shall be provided by the laboratory. The integrity of all original electronic data deliverables shall be maintained. This shall be accomplished via the generation of copies of each electronic deliverable provided by the laboratory. The original electronic deliverable shall be provided to the project manager for inclusion in the project file. A copy of the original electronic deliverable shall be placed in the Database Record File. The second copy shall be maintained by the MIS Manager (or designee) to be used as a working copy.

5.4 Sample Tracking Forms

Updated versions of the sample tracking form for each relevant project shall be maintained by the Database Record Custodian. The Sample Tracking Forms shall be updated any time additional Chain-of-Custody Forms are received from a FOL or sampling technician, or at any time that data are received from a laboratory, or at any time that validation of a given data package (sample delivery group) is completed. The Data Validation Coordinator shall inform the Database Record Custodian of the receipt of any data packages from the laboratory and of completion of validation of a given data package to facilitate updating of the Sample Tracking Form. The Database Record Custodian shall place a revised copy of the Sample Tracking Form in the Database Record File anytime it has been updated. Copies of the updated Sample Tracking Form shall also be provided to the project manager to apprise the project manager of sample package receipt, completion of validation, etc.

5.5 Chain-of-Custody Forms

The Chain-of-Custody Forms for all sampling efforts will be used as the basis for (1) updating the Sample Tracking Form, and (2) confirming that all required samples and associated analyses have been completed. It shall be the responsibility of the FOL (or sample technician) to provide a photocopy of all Chain-of-Custody Forms to the Database Record Custodian immediately upon completion of a sampling effort. The Database Record Custodian shall then place the copies of the Chain-of-Custody Form(s) in the Database Record File. Upon receipt of a sample data package from an analytical laboratory, the Data Validation Coordinator shall provide a copy of the laboratory Chain-of-Custody Form to the Database Record Custodian. The Database Record Custodian shall use this copy to update the Sample Tracking Summary and shall place the copy of the laboratory-provided Chain-of-Custody Form in the Database Record File. The photocopy of the laboratory-provided Chain-of Custody Form shall be stapled to the previously filed field copy. Upon receipt of all analytical data, two copies of the Chain-of-Custody will therefore be in the file. Review of the Chain-of-Custody Forms will therefore be a simple mechanism to determine if all data have been received. Chain-of-Custody is addressed in SOP SA-6.1.

5.6 Data Validation Letters

All data validation deliverables (or raw data summaries if validation is not conducted) shall be provided for inclusion in both the Database Record File and the project file. If USEPA regional- or client-specific requirements are such that Form Is (or similar analytical results) need not be provided with the validation deliverable, copies of such results must be appended to the deliverable. It is preferable, although not essential that the validation qualifiers be hand-written directly on the data summary forms. The data validation deliverables (and attendant analytical summaries) will provide the basis for direct comparison of the database printout and the raw data and qualifiers.

5.7 Historical Data

At the direction of the Project Manager, historical data may also be included in a project-specific analytical database. In the event that historical data are germane to the project, hardcopy of the historical data must be included in the Database Record File. Historical data may be maintained in the form of final reports or as raw data. The information contained in the historical data file must be sufficient to identify its origin, its collection date, the sample location, the matrix, and any and all other pertinent information. All available analytical data, Chain-of-Custody Forms, boring logs, well construction logs, sample location maps, shall be photocopied by the Project Manager (or designee) and placed in one or more 3-ring binders. All information shall be organized chronologically by matrix. It shall be the responsibility of the Project Manager (or designee) to ensure that all inconsistencies between analytical data, Chain-of-Custody Forms, boring logs, sample log sheets, and field logbooks are identified and corrected. The Project Manager (or designee) shall decide which nomenclature is appropriate and edit, initial and date all relevant forms. Data entry may only be performed on information that has undergone the aforementioned editing process, thereby having a direct correlation between hardcopy information and what will become the electronic database.

6.0 RECORDS

Records regarding database preparation and quality assurance review include all those identified in the previous section. Upon completion of the database task, records from the file will be forwarded to the Project Manager for inclusion in the project file, or will be placed in bankers boxes (or equivalent) for storage. The final records for storage shall include the following minimum information on placards placed on both the top and end of the storage box:

Database Record File
PROJECT NUMBER: ____
SITE NAME: _________
DATE FILED: __/__/__
SUMMARY OF CONTENTS ENCLOSED
BOX _ OF _

Project- or program-specific record keeping requirements shall take precedence over the record keeping requirements of this SOP.

ATTACHMENT A

MIS REQUEST FORM

Tetra Tech NUS, Inc.

Project Name: ____________________ Request Date: ____________________
CTO: ____________________ Date Data Available for Production: ____________________
Project Manager: ____________________ Request in Support of: ____________________
Requestor: ____________________ Database Lead: ____________________
Program/Client: ____________________ GIS Lead: ____________________
State/EPA Region: ____________________ Statistics Lead: ____________________
Risk Lead: ____________________
Site Name(s) (Area, OU, etc.): ____________________
Sampling Date(s): ____________________
Matrix: ☐ GW ☐ SO ☐ SD ☐ SW ☐ Other: ____________________

Labels: ☐ Labels needed for an upcoming sampling event ________ Total # of Samples
________ Estimated Hours — Additional Instructions: ____________________
________ Due Date
________ Complete ETS Charge No.
________ FOL

Data Entry:
☐ Chemical data needs to be entered from hardcopy ________ Estimated # of Samples
☐ Chemical data needs to be formated electronically
☐ Field analytical data needs to be entered from hardcopy
☐ Geologic data needs to be entered from hardcopy
☐ Hydrology data needs to be entered from hardcopy
________ Estimated Hours — Additional Instructions: ____________________
________ Due Date
________ Complete ETS Charge No.

Tables:
☐ Full Data Printout
☐ Summary of Positive Hits
☐ Occurance and Distribution ☐ with criteria
☐ Sampling Analytical Summary
☐ Other:
________ Estimated Hours — Additional Instructions: ____________________
________ Due Date
________ Complete ETS Charge No.

GIS:
☐ General Facility Location
☐ Site Location
☐ Potentiometric Contours/Groundwater Flow
☐ Sample Location Proposed
☐ Sample Location Existing
☐ Tag Map Single Round
☐ Tag Map Multiple Round
☐ Isoconcentrations
☐ Chart Map
☐ 3D Visualization
☐ EGIS CD
☐ Other:
________ Estimated Hours — Additional Instructions: ____________________
________ Due Date
________ Complete ETS Charge No.

Statistics: ☐ Yes
________ Estimated Hours — Additional Instructions: ____________________
________ Due Date
________ Complete ETS Charge No.

Geostatistics: ☐ Yes
________ Estimated Hours — Additional Instructions: ____________________
________ Due Date
________ Complete ETS Charge No.

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number GH-1.2	Page 1 of 9
		Effective Date 09/03	Revision 2
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT		Approved D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

5.0 PROCEDURES

Accurate, valid and useful groundwater monitoring requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To insure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

5.1 Preliminary Evaluation

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.
- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.
- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.
- The soil profile and stratigraphy.
- The borehole depth and diameter.
- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.
- The total depth of the well.
- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.
- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

5.2 Field Inspection

During the onsite inspection of existing monitoring wells, features to be noted include:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be noted:

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and well obstruction. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

5.3 Water Level (Hydraulic Head) Measurements

5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

All groundwater level measurements shall be made to the nearest 0.01 foot, and recorded in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading. The total depth of the well shall be measured and recorded, if not already known. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, there shall be a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level readings shall be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be read in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such readings shall be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map shall be made in the shortest practical time to minimize affects due to weather changes.

5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

5.3.3 Methods

Water levels can be measured by several different techniques, but the same steps shall be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened.

2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):

   - Well number.
   - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize.
   - Time and day of the measurement.
   - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

5.3.4 Water Level Measuring Devices

Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, the probe shall be lowered slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. The transducer is wired into a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly-used logs which will indicate saturated/unsaturated conditions include the spontaneous potential (SP) log and the neutron log.

5.3.5 Data Recording

Water level measurements, time, data, and weather conditions shall be recorded in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements shall be measured from a known reference point. The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point shall be marked with permanent ink on the casing since the top of the casing may not be entirely level. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within the well.

5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device shall be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices shall be calibrated to 0.01 foot accuracy and any adjustments/corrections shall be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings shall be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations will be entered on the sheet when they become available.

5.4 Equipment Decontamination

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

5.5 Health and Safety Considerations

Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Initial monitoring of the well headspace and breathing zone concentrations using a PID or FID shall be performed to determine required levels of protection. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

6.0 RECORDS

A record of all field procedures, tests and observations must be recorded in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation.

ATTACHMENT A
MONITORING WELL INSPECTION SHEET

Monitoring Well Inspection Sheet

Project Name: ________________ Date: ______________

Location: ____________ Time: ______________

Tidally Influenced: Y / N Personnel: ________________

Field Measurements				
Well ID	PID Reading PPM	Depth to Water *	Total Depth *	Flush Mt./ Stick-up

Well Construction Details (Taken from construction logs)		
Total Depth *	Ground Elev.	Top/Btm Screen *

Check List:

Riser Pipe Material:
Riser Notched for Surveyors:
Well ID Tag In-place:
Well security:
Photo taken:

Condition of Well:

Protective Case:
Riser:
Well Pad:
Other:

Presence/Evidence of:

Standing Water Around Well:
Existing Sampling Equipment:
Sediment build-up in Well Btm:

Comments:

** = Measurements are from the top of the inner case to the nearest 0.01'*

ATTACHMENT B
GROUNDWATER LEVEL MESUREMENT SHEET

Tetra Tech NUS, Inc.

GROUNDWATER LEVEL MEASUREMENT SHEET

Project Name: ____________ **Project No.:** ____________
Location: ____________ **Personnel:** ____________
Weather Conditions: ____________ **Measuring Device:** ____________
Tidally Influenced: Yes ____ No ____ **Remarks:** ____________

Well or Piezometer Number	Date	Time	Elevation of Reference Point (feet)*	Water Level Indicator Reading (feet)*	Thickness of Free Product (feet)*	Comments

* All measurements to the nearest 0.01 foot, from surveyed mark (unless noted)

Page ____ of ____

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

July 30, 1996
Revision 2

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION I

LOW STRESS (low flow) PURGING AND SAMPLING PROCEDURE FOR THE COLLECTION OF GROUND WATER SAMPLES FROM MONITORING WELLS

I. SCOPE & APPLICATION

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Proper well construction and development cannot be overemphasized, since the use of installation techniques that are appropriate to the hydrogeologic setting often prevents "problem well" situations from occurring. It is also recommended that as part of development or redevelopment the well should be tested to determine the appropriate pumping rate to obtain stabilization of field indicator parameters with minimal drawdown in shortest amount of time. With this information field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake. However, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permealability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help insure that the low stress procedure will not underestimate contaminant concentrations. The Sampling and Analysis Plan must provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization) c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

Changes to this SOP should be proposed and discussed when the site Sampling and Analysis Plan is submitted for approval. Subsequent requests for modifications of an approved plan must include adequate technical justification for proposed changes. All changes and modifications must be approved before implementation in field.

II. EQUIPMENT

A. Extraction device

Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or

Teflon).

Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11).

The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

B. Tubing

Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics.

PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample.

Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals.

The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates.

Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.

C. Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each record.

D. Flow measurement supplies (e.g., graduated cylinder and stop watch).

E. Interface probe, if needed.

F. Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.

G. Indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments. Analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.

H. Decontamination supplies (for example, non-phosphate detergent, distilled/deionized water, isopropyl alcohol, etc.).

I. Logbook(s), and other forms (for example, well purging forms).

J. Sample Bottles.

K. Sample preservation supplies (as required by the analytical methods).

L. Sample tags or labels.

M. Well construction data, location map, field data from last sampling event.

N. Well keys.

O. Site specific Sample and Analysis Plan/Quality Assurance Project Plan.

P. PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.

III. PRELIMINARY SITE ACTIVITIES

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

IV. PURGING AND SAMPLING PROCEDURE

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump

Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there is two feet or less of standing water in the well.

2. Measure Water Level

Before starting pump, measure water level. If recording pressure transducer is used-initialize starting condition.

3. Purge Well

3a. Initial Low Stress Sampling Event

Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

Monitor and record water level and pumping rate every three to five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

3b. Subsequent Low Stress Sampling Events

After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters

During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:

turbidity (10% for values greater than 1 NTU),
DO (10%),
specific conductance (3%),
temperature (3%),
pH (± 0.1 unit),
ORP/Eh (± 10 millivolts).

All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

5. Collect Water Samples

Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

VOC samples should be collected first and directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples: (1) add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing; (2) insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing; (3) collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check analytical methods (e.g. EPA SW-846, water supply, etc.) for additional information on preservation. Check pH for all samples requiring pH adjustment to assure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter size (0.45 um is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of ground water prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in ground water for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities

If recording pressure transducer is used, remeasure water level with tape.

After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a "silting" problem or if confirmation of well identity is needed.

Secure the well.

V. DECONTAMINATION

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1

The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

Flush the equipment/pump with potable water.

Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.

Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.

Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.

Flush with distilled/deionized water. The final water rinse must not be recycled.

Procedure 2

Steam clean the outside of the submersible pump.

Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

VI. FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

Field duplicate.

Matrix spike.

Matrix spike duplicate.

Equipment blank.

Trip blank (VOCs).

Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

VII. FIELD LOGBOOK

A field log shall be kept to document all ground water field monitoring activities (see attached example matrix), and record all of the following:

Well identification.

Well depth, and measurement technique.

Static water level depth, date, time and measurement technique.

Presence and thickness of immiscible liquid (NAPL) layers and detection method.

Pumping rate, drawdown, indicator parameters values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.

Well sampling sequence and time of each sample collection.

Types of sample bottles used and sample identification numbers.

Preservatives used.

Parameters requested for analysis.

Field observations during sampling event.

Name of sample collector(s).

Weather conditions.

QA/QC data for field instruments.

Any problems encountered should be highlighted.

Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

VIII. DATA REPORT

Data reports are to include laboratory analytical results, QA/QC information, and whatever field logbook information is needed to allow for a full evaluation of data useability.

EXAMPLE (Minimum Requirements) Page____of____

Well PURGING-FIELD WATER QUALITY MEASUREMENTS FORM

Location (Site/Facility Name)______________________ Depth to ________/________ of screen
Well Number________________ Date____________________ (below MP) top bottom
Field Personnel____________________________________ Pump Intake at (ft. below MP)______________
Sampling Organization______________________________ Purging Device; (pump type)______________
Identify MP

Clock Time 24 HR	Water Depth below MP ft	Pump Dial[1]	Purge Rate ml/min	Cum. Volume Purged liters	Temp. °C	Spec. Cond.[2] µS/cm	pH	ORP/ Eh[3] mv	DO mg/L	Turb-idity NTU	Comments

1. Pump dial setting (for example: hertz, cycles/min, etc).
2. µSiemens per cm(same as µmhos/cm)at 25 °C.
3. Oxidation reduction potential (stand in for Eh).

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number SA-6.1	Page 1 of 11
		Effective Date 02/04	Revision 3
		Applicability Tetra Tech NUS, Inc.	
		Prepared Earth Sciences Department	
Subject NON-RADIOLOGICAL SAMPLE HANDLING		Approved D. Senovich	

TABLE OF CONTENTS

SECTION **PAGE**

ATTACHMENTS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (ұ261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (ұ261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H_2SO_4
- Nitric Acid - HNO_3
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4°C. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO_3, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4°C, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H_2SO_4)	1 part concentrated H_2SO_4: 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO_3)	Undiluted concentrated HNO_3	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

  If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

  Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory <u>before</u> sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed <u>prior to</u> the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.

- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)

- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration			Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER						
Organics (GC&GC/MS)	VOC	Low	Borosilicate glass	2 x 40 mL	Cool to 4°C HCl to ≤ 2	14 days[9]
	Extractables SVOCs and pesticide/PCBs)	(Low	Amber glass	2x2 L or 4x1 L	Cool to 4°C	7 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticide/PCBs)	(Medium	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals	Low	High-density polyethylene	1 L	HNO_3 to pH ≤2	6 months (Hg-28 days)
		Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide	Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide	Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	14 days
SOIL						
Organics (GC&GC/MS)	VOC		EnCore Sampler	(3) 5 g Samplers	Cool to 4°C	48 hours to lab preservation
	Extractables SVOCs and pesticides/PCBs)	(Low	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
	Extractables SVOCs and pesticides/PCBs)	(Medium	Wide-mouth glass	8 oz.	Cool to 4°C	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium		Wide-mouth glass	8 oz.	Cool to 4°C	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorganic	High Hazard		Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All		Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All		Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction
AIR						
Volatile Organics	Low/Medium		Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4°C	5 days recommended

1 All glass containers should have Teflon cap liners or septa.
2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4°C; NaOH to pH 12; 0.6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH 2; H_2SO_4 to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4°C	48 hours
Oil & Grease	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4°C; HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4°C	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4°C; H_2SO_4 to pH 2	28 days
Residue, Total	P, G	Cool, 4°C	7 days
Residue, Filterable (TDS)	P, G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, Settleable	P, G	Cool, 4°C	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific Conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS (Cont'd):			
Sulfide	P, G	Cool, 4°C; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4°C	48 hours
METALS:[7]			
Chromium VI (Hexachrome)	P, G	Cool, 4°C	24 hours
Mercury (Hg)	P, G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO_3 to pH 2	6 months
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] HCl to pH 2 [9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4°C; 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5 [10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Benzidines[11],[12]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines[11],[14]	G, Teflon-lined cap	Cool, 4°C; store in dark; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PCBs[11]	G, Teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs)[11],[14]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF)[11]	G, Teflon-lined cap	Cool, 4°C; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE THREE

(1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.
(3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
(5) Should only be used in the presence of residual chlorine.
(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
(7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
(9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
(12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.
(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
(14) For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

TETRA TECH NUS, INC.	STANDARD OPERATING PROCEDURES	Number: SA-6.3	Page: 1 of 12
		Effective Date: 09/03	Revision: 2
		Applicability: Tetra Tech NUS, Inc.	
		Prepared: Earth Sciences Department	
Subject: FIELD DOCUMENTATION		Approved: D. Senovich	

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs and reports generally initiated and maintained for documenting Tetra Tech NUS field activities.

2.0 SCOPE

Documents presented within this procedure (or equivalents) shall be used for all Tetra Tech NUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None

4.0 RESPONSIBILITIES

Project Manager (PM) - The Project Manager is responsible for obtaining hardbound, controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The Field Operations Leader is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports illustrated in this guideline (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time-frame.

5.0 PROCEDURES

5.1 Site Logbook

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major onsite activities are documented. At a minimum, the following activities/events shall be recorded or referenced (daily) in the site logbook:

- All field personnel present
- Arrival/departure of site visitors
- Time and date of H&S training
- Arrival/departure of equipment
- Time and date of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation, etc.
- Daily onsite activities performed each day
- Sample pickup information
- Health and Safety issues (level of protection observed, etc.)
- Weather conditions

A site logbook shall be maintained for each project. The site logbook shall be initiated at the start of the first onsite activity (e.g., site visit or initial reconnaissance survey). Entries are to be made for every day that onsite activities take place which involve Tetra Tech NUS or subcontractor personnel. Upon completion of the fieldwork, the site logbook must become part of the project's central file.

The following information must be recorded on the cover of each site logbook:

- Project name
- Tetra Tech NUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2), but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, the measurements and equipment used must either be recorded in the site logbook or reference must be made to the field notebook in which the measurements are recorded (see Attachment A).

All logbook, notebook, and log sheet entries shall be made in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, the entry shall be crossed out with a single strike mark, and initialed and dated. At the completion of entries by any individual, the logbook pages used must be signed and dated. The site logbook must also be signed by the Field Operations Leader at the end of each day.

5.1.2 Photographs

When movies, slides, or photographs are taken of a site or any monitoring location, they must be numbered sequentially to correspond to logbook/notebook entries. The name of the photographer, date, time, site location, site description, and weather conditions must be entered in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided, since they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend upon the subject matter, type of camera (digital or film), and the processing it requires. Film used for aerial photography, confidential information, or criminal investigation require chain-of-custody procedures. Once processed, the slides of photographic prints shall be consecutively numbered and labeled according to the logbook/notebook descriptions. The site photographs and associated negatives and/or digitally saved images to compact disks must be docketed into the project's central file.

5.2 <u>Field Notebooks</u>

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 Field Forms

All Tetra Tech NUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs contingent upon client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOP.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample Log Sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. A log sheet must be completed for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Adhesive labels must be completed and applied to every sample container. Sample labels can usually be obtained from the appropriate Program source electronically generated in-house, or are supplied from the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record Form

The Chain-of-Custody (COC) Record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site. One carbonless copy of the completed COC form is retained by the field crew, one copy is sent to the Project Manager (or designee), while the original is sent to the laboratory. The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing vials for VOC analysis or the cooler with the air bill attached. The air bill should then state how many coolers are included with that shipment. An example of a Chain-of-Custody Record form is provided as Attachment C. Once the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed COC form (any discrepancies between the sample labels and COC form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the Tetra Tech NUS Project Manager). The COC form is signed and copied. The laboratory will retain the copy while the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The Custody seal is an adhesive-backed label. It is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. The COC seals are signed and dated by the sampler(s) and affixed across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). COC seals may be available from the laboratory; these seals may also be purchased from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Field Analytical Log Sheets are used to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

A Groundwater Level Measurement Sheet must be filled out for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. The Pumping Test Data Sheet facilitates this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be laid out in advance.

5.3.2.3 Packer Test Report Form

A Packer Test Report Form must be completed for each well upon which a packer test is conducted.

5.3.2.4 Boring Log

During the progress of each boring, a log of the materials encountered, operation and driving of casing, and location of samples must be kept. The Summary Log of Boring, or Boring Log is used for this purpose and must be completed for each soil boring performed. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a PID or FID), these readings must be entered on the boring log at the appropriate depth. The "Remarks" column can be used to subsequently enter the laboratory sample number, the concentration of key analytical results, or other pertinent information. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

A Monitoring Well Construction Details Form must be completed for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation, or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Monitoring Well Materials Certificate of Conformance should be used as the project directs to document all materials utilized during each monitoring well installation.

The Monitoring Well Development Record should be used as the project directs to document all well development activities.

5.3.2.8 Miscellaneous Field Forms - QA and Checklists

Container Sample and Inspection Sheet should be used as the project directs each time a container (drum, tank, etc.) is sampled and/or inspected.

QA Sample Log Sheet should be used at the project directs each time a QA sample is colleted, such as Rinsate Blank, Source Blank, etc.

Field Task Modification Request (FTMR) will be prepared for all deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Copies of all FTMRs will be maintained with the onsite planning documents and originals will be placed in the final evidence file.

The Field Project Daily Activities Check List and Field Project Pre-Mobilization Checklist should be used during both the planning and field effort to assure that all necessary tasks are planned for and completed. These two forms are not a requirement but a useful tool for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring or test equipment is necessary to assure the proper operation and response of the equipment, to document the accuracy, precision or sensitivity of the measurement, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. An Equipment Calibration Log must be maintained for each electronic measuring device used in the field; entries must be made for each day the equipment is used or in accordance with the manufacturer's recommendations.

5.4 Field Reports

The primary means of recording onsite activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation, but are not easily useful for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain onsite for extended periods of time and are thus not accessible for timely review by project management.

5.4.1 Daily Activities Report

To provide timely oversight of onsite contractors, Daily Activities Reports are completed and submitted as described below.

5.4.1.1 Description

The Daily Activities Report (DAR) documents the activities and progress for each day's field work. This report must be filled out on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring which involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the Daily Activities Report to the Field Operations Leader (FOL) for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DAR reports are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the Project Manager.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

It should be noted that in addition to summaries described herein, other summary reports may also be contractually required.

All Tetra Tech NUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF TETRA TECH NUS FIELD FORMS FOUND ON THE TTNUS INTRANET SITE. HTTP://INTRANET.TTNUS.COM CLICK ON FIELD LOG SHEETS

Groundwater Sample Log Sheet
Surface Water Sample Log Sheet
Soil/Sediment Sample Log Sheet
Container Sample and Inspection Sheet
Geochemical Parameters (Natural Attenuation)
Groundwater Level Measurement Sheet
Pumping Test Data Sheet
Packer Test Report Form
Boring Log
Monitoring Well Construction Bedrock Flush Mount
Monitoring Well Construction Bedrock Open Hole
Monitoring Well Construction Bedrock Stick Up
Monitoring Well Construction Confining Layer
Monitoring Well Construction Overburden Flush Mount
Monitoring Well Construction Overburden Stick Up
Test Pit Log
Monitoring Well Materials Certificate of Conformance
Monitoring Well Development Record

Daily Activities Record
Field Task Modification Request
Hydraulic Conductivity Test Data Sheet
Low Flow Purge Data Sheet
QA Sample Log Sheet
Equipment Calibration Log
Field Project Daily Activities Checklist
Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: ______________________ DATE: ______________________

SITE LEADER: ____
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
________	________	________
________	________	________
________	________	________

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was ______________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well ______.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _______.
4. Well ______ drilled. Rig geologist was ___________________. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _________.
8. Test pit _______ dug with cuttings placed in dump truck. Rig geologist was _______________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

____

Field Operations Leader

ATTACHMENT B

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Site: Location:	
Sample No:		Matrix:
Date:	Time:	Preserve:
Analysis:		
Sampled by:	Laboratory:	

ATTACHMENT C

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER 3413 | PAGE ____ OF _____

PROJECT NO:	FACILITY:	PROJECT MANAGER	PHONE NUMBER	LABORATORY NAME AND CONTACT:
SAMPLERS (SIGNATURE)		FIELD OPERATIONS LEADER	PHONE NUMBER	ADDRESS
		CARRIER/WAYBILL NUMBER		CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G)
PRESERVATIVE USED
TYPE OF ANALYSIS

DATE YEAR ____	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS									COMMENTS

1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL

Signature

Date

CUSTODY SEAL

CUSTODY SEAL

Date

Signature